5.3 Water Quality

This section discusses potential short-term impacts on groundwater quality from operations and construction of Hanford solid waste (HSW) disposal sites and related facilities and potential long-term impacts on groundwater and the Columbia River from contaminant releases from HSW disposal facilities after site closure in 2046 based on conservative assumptions used in this HSW EIS. Potential short-term impacts during the period of operations and construction are discussed in Section 5.3.1. An overview of assessment methods used to determine the potential long-term impacts to groundwater and the Columbia River are presented in Section 5.3.2. Detailed information on the long-term assessment methods and results are provided in Volume II, Appendix G. Section 5.3.3 discusses the use of immobilized low-activity waste (ILAW) performance assessment calculations to support this EIS. Details from the water quality analysis presented in Section 5.3.4 and in Volume II, Appendix G are used in the preparation of estimates of potential impacts on public health and safety, as provided in Section 5.11.

As a result of wastewater management activities during past Hanford Site operations, groundwater beneath the 200 Areas has been contaminated with radionuclides and non-radioactive chemicals. The contaminants emanating from the 200 Areas are moving toward the Columbia River. Radioactive contaminants present in groundwater beneath the 200 Areas that exceed values cited in Table 4.10 (see Section 4.5.3) are tritium, strontium-90, technetium-99, iodine-129, plutonium, cesium-137, total alpha, total beta, and uranium. Hazardous chemical contaminants present at levels exceeding values in Table 4.10 include nitrate, fluoride, chromium, carbon tetrachloride, trichloroethene, cyanide, tetrachloroethene, and cis-1, 2-dichloroethene. None of these contaminants is thought to have originated from the LLBGs being considered in this EIS (Hartman et al. 2002).

5.3.1 Potential Short-Term Impacts of Operations and Construction Activities

In the HSW management facilities, water is derived from the Hanford Site Export Water System is used for dust suppression during operations and construction. The Hanford Site Export Water System extracts potable water for fire suppression and industrial use in the Central Plateau from the Columbia River intake locations in the 100 D Area. Water from the export system also is expected to be used at existing sanitary facilities and would be disposed of after treatment. Because most of these operational water discharges would occur in uncontaminated areas, the discharges would not be expected to have a substantial effect on the groundwater system from leaching or the driving force of the wastes. Potential groundwater quality impacts would not be expected. In the case of capping the HSW disposal facilities at closure where water is used for short-term dust suppression, the 25-cm (10-in) layer of asphalt at the base of the cap is expected to divert water away from the waste and is not expected to result in impacts to groundwater quality. Use of process water is not anticipated for any of the HSW management facilities and is not considered further in terms of water quality.

Solid LLW disposed of after 1988 in the HSW disposal facilities is largely dry solid waste with limited amounts of free liquid that could otherwise result in waste leaching and release through the vadose zone and into the groundwater. Since that time, LLW has been categorized into Category (Cat) 1 and Cat 3 LLW based on stringent waste acceptance criteria for radionuclide inventory content. Further, beginning in 1995, systematic use of waste containment and containers, such as emplacing all wastes in steel boxes, drums, high-integrity containers (HIC), and grouted waste forms, was implemented to minimize leaching and release of contaminants during the period of operations. In addition, MLLW is being disposed of in RCRA-compliant trenches with a liner system to facilitate monitoring, management, and treatment of leachate during operations (see Section 3.1).

Because waste containment using containers described above was not systemically used prior to 1995, contaminants contained in solid LLW disposed of in LLBGs prior to 1995 offer the highest potential for leaching and release into the vadose zone prior to site closure. The analysis conducted for this HSW EIS conservatively evaluated the potential impacts of these earlier disposals by evaluating the effect of higher infiltration rates during operations. Results of analyses of earlier disposal facilities used release and vadose zone infiltration rates of 5 cm/yr, a rate reflective of managed bare surface soil conditions over the older disposal areas during the operations phase. Mobile contaminants (such as technetium-99 and iodine-129) disposed of before 1995 were estimated to arrive several hundred years before mobile contaminants disposed of after 1995. Peak concentrations of technetium-99 and iodine-129 were estimated to arrive at downgradient locations between years 2050 and 2100 from 200 East Area locations and year 2150 and 2200 from 200 West Area locations. Descriptions of the underlying assumptions and resulting estimated impacts (that is, contaminant concentration levels and peak arrival times) from these analyses are provided in detail in Volume II, Appendix G.

5.3.2 Methods for Assessment of Potential Long-Term Impacts

The groundwater exposure pathway considers the long-term release of contaminants from a variety of LLW and MLLW downward through the vadose zone underlying the HSW disposal facilities and laterally through the unconfined aquifer immediately underlying the vadose zone to the Columbia River. The LLBG are all located in the 200 Areas, and the physical area of potential groundwater impact is the unconfined aquifer bounded laterally by the Rattlesnake Hills to the west and southwest, by the Columbia River to the north and east, and by the Yakima River to the south (see Section 4.5.3, Figure 4.17).

The sequence of calculations used in the long-term assessment required using a suite of process models that estimated source-term release, vadose zone flow and transport, and groundwater flow and transport. The computational framework for these process models and relationship of software elements is schematically illustrated in Figure 5.1.

Wastes considered in this assessment include previously disposed of wastes and wastes to be disposed of in the HSW disposal facilities (for purposes of analysis, year 2007 was assumed to be the date when new disposal facilities would be operational):

- Previously disposed of LLW, which includes:
  - LLW disposed of in LLBGs between 1962 and 1970 (referred to as pre-1970 LLW in this section).
  - LLW disposed of in LLBGs after 1970, but before October 1987 (referred to as 1970–1987 LLW in this section).

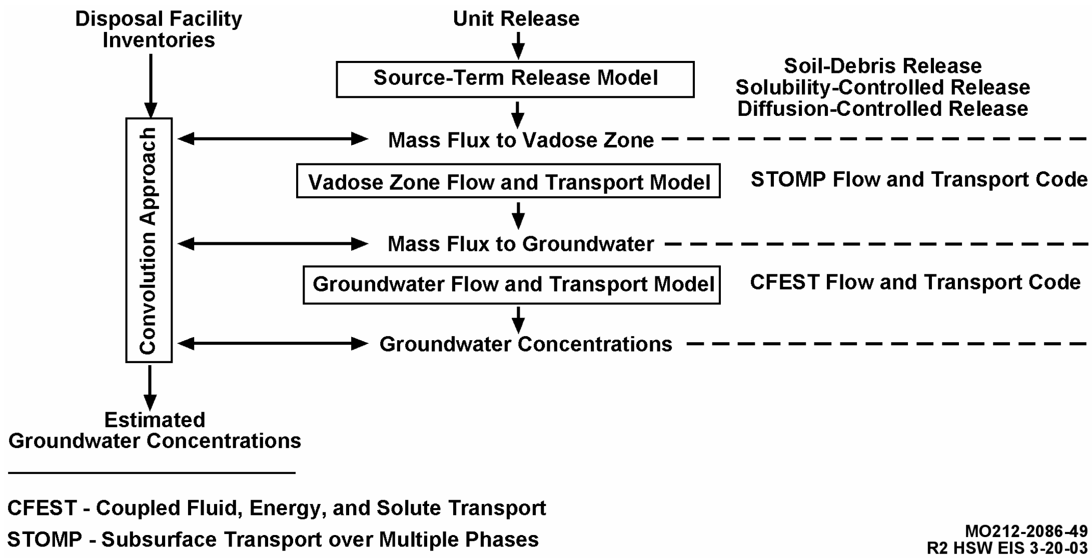


Figure 5.1. Schematic Representation of Computational Framework and Codes Used in the HSW EIS

- LLW disposed of in LLBGs after October 1987, but before 1995 (referred to as 1988–1995 LLW in this section).

- Cat 1 LLW, which includes:
  - Cat 1 LLW disposed of in the LLBGs after 1995 including Cat 1 LLW forecasted to be disposed of through 2007 (referred to as Cat 1 LLW [1996–2007] in this section).
  - Cat 1 LLW disposed of after 2007 including Cat 1 LLW forecasted to be disposed of through 2046 (referred to as Cat 1 LLW disposed of after 2007 in this section). For purposes of analysis, year 2007 was assumed to be the date when new disposal facilities would be operational.

- Cat 3 LLW, which includes:
  - Cat 3 and greater than Cat 3 (GTC3) LLW disposed of in the LLBGs after 1995 including Cat 3 LLW forecasted to be disposed of through 2007 (referred to as Cat 3 LLW [1996–2007] in this section).
  - Cat 3 and GTC3 LLW disposed of after 2007 including Cat 3 LLW forecasted to be disposed of through 2046 (referred to as Cat 3 LLW disposed of after 2007 in this section).

- MLLW, which includes:
  - MLLW disposed of after 1996 including MLLW forecasted to be disposed of through 2007 (referred to as MLLW [1996–2007] in this section). MLLW received since 1988 has been in storage awaiting final treatment.

– MLLW disposed of after 2007 including MLLW forecasted to be disposed of through 2046 (referred to as MLLW disposed of after 2007 in this section).

- Melters from the tank waste treatment program.

- ILAW from the tank waste treatment program.

Inventories of retrievably stored transuranic (TRU) waste in trenches and caissons located in the LLBGs were not evaluated for their potential groundwater quality impacts because the TRU waste will be retrieved and sent to the Waste Isolation Pilot Plant for disposal. TRU waste is stored in containers, and the configuration in which the TRU waste containers are stored (including coverings to prevent intrusion of water and asphalt storage pads) provides additional protection from releases. Procedures require that waste container integrity and containment inspections be performed during the retrieval. Any releases would be characterized and addressed consistent with existing procedures and plans.

Although not specifically required by current DOE standards for LLW management, this assessment examined potential groundwater quality impacts for up to 10,000 years after the operational period. Current requirements under the guidelines for a performance assessment of LLW disposal facilities, as prescribed in (DOE 2001b), focus on potential impacts during the first 1,000 years after disposal.

This groundwater assessment was performed using a combination of screening techniques and numerical modeling. The groundwater modeling results estimate contaminant concentrations in the groundwater associated with selected alternatives evaluated in this HSW EIS from the end of waste operations in 2046 up to 10,000 years from 2046. This analysis also evaluates potential early waste release and contaminant transport from wastes disposed of before 1996, including pre-1970 LLW, 1970-1987 LLW, and 1988–1995 LLW, and examines the potential for release and vadose zone transport during the operational period.

The lines of analysis (LOAs) used in this comparative assessment were located on the Hanford Site along lines approximately 1 km (0.6 mi) downgradient from the 200 East and West Areas, at ERDF, and near the Columbia River, as shown in Figure 5.2. Additional analyses of potential groundwater quality impacts for a new combined-use facility (as presented for Alternative Groups D_1, D_2, and D_3), are presented in Section 5.3.6 and in Volume II, Appendix G, Section G.5, and provide a perspective on the relative impact at waste management boundaries immediately downgradient of the aggregate waste disposal area versus potential impacts at the 1-km LOAs. A similar impact analysis is provided for LLW and MLLW disposed of before 2007 for another perspective.

All locations were selected based on simulated transport results of unit releases at selected HSW disposal facilities. These LOAs in each area are not meant to represent points of regulatory compliance, but rather common locations to facilitate a comparison of the waste management activities and locations defined for each alternative group. Constituent concentrations presented for each alternative group from specific waste category releases represent maximum concentrations estimated along these LOAs. Because of the variation in the location of the different waste types and category releases for a given alternative group, the estimated maximum concentrations calculated from a specific waste category release may not correspond to the same point on the line of analysis for every waste category and

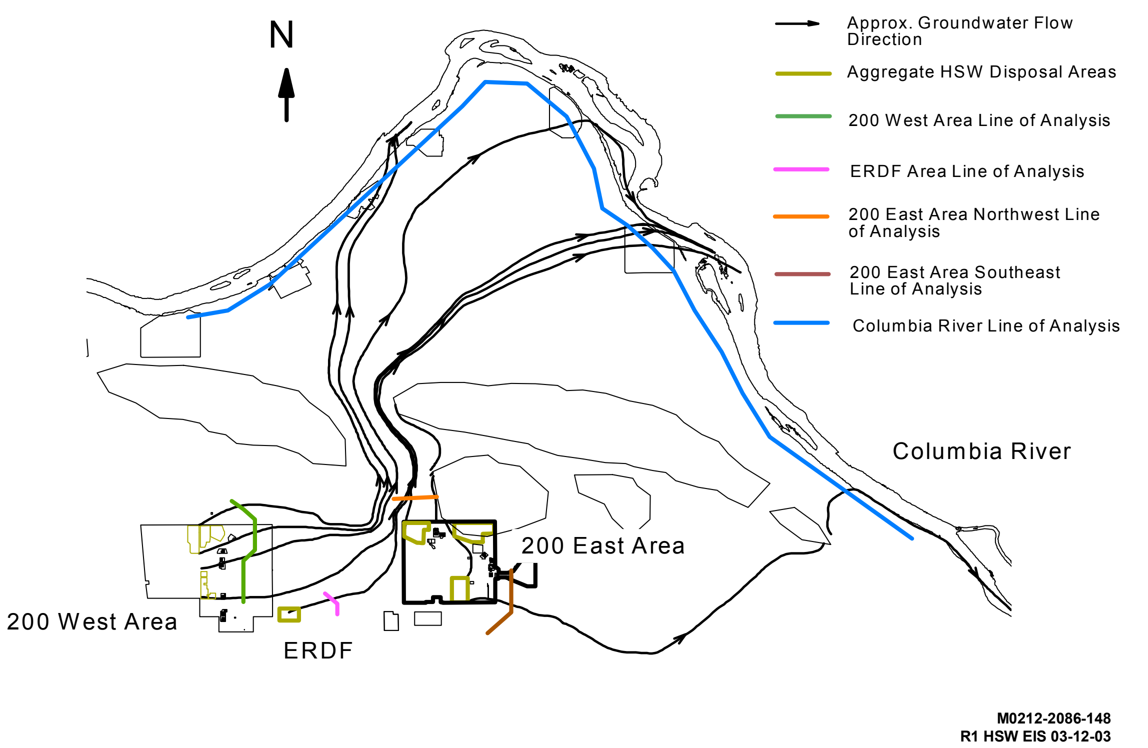


Figure 5.2. LOAs Used in Comparing Potential Long-Term Groundwater Quality Impacts

alternative group. Combined concentration levels presented for each LOA and alternative group reflect the summation of estimated concentration levels regardless of their position on the LOA. As a consequence, the actual maximum concentrations at a given point along the LOA would be overestimated when combining concentration levels.

Delineation of potential waste impacts in the 200 East Area required two different LOAs. One LOA, designated as the 200 East Northwest (NW) LOA, is used to evaluate concentrations in groundwater migrating northwest from the 200 East Area. Another LOA, designated as the 200 East Southeast (SE) LOA, is used to evaluate concentrations in groundwater migrating southeast from the 200 East Area.

The HSW disposal facilities contain over 100 radioactive and non-radioactive waste constituents. Potential impacts to groundwater within the 10,000-year period of analysis were based primarily on the overall mobility of the constituents. To establish their relative mobility, the constituents were grouped based on their mobility in the vadose zone and underlying unconfined aquifer. Contaminant mobility classes were used rather than the individual mobility of each contaminant because of the uncertainty involved in determining the mobility of individual constituents. The mobility classes were selected based on relatively narrow ranges of mobility. Some of the constituents, such as iodine and technetium, would move at the same rate as water whether in the vadose zone or underlying groundwater. The movement of other constituents in water, such as americium, cesium, plutonium, and strontium, would be retarded by interaction with soil and rock.

The constituents considered in this assessment have a broad range of mobility when their affinity to being sorbed during transport in the vadose zone and groundwater environment is considered. The flow and transport models used in this analysis account for these differences in mobility by the use of a factor commonly referred to as the retardation factor (Rf). This factor, which relates the velocity of the contaminant to the velocity of pore water, is typically calculated using a distribution coefficient, or K_d, which has units of mL/g. This parameter is a measure of sorption and is the ratio of the quantity of the solute adsorbed per gram of solid to the amount of solute remaining in solution (Kaplan et al. 1995). Values of K_d for the constituents range from 0 mL/g (in which the contaminant movement in water is not retarded) to more than 40 mL/g (in which the contaminant moves at a much slower rate than water).

The constituents in the LLW inventory were grouped and modeled according to well-established K_ds for each constituent, or a conservative K_d where a range of K_ds is known for a particular constituent. The constituent mobility classes, based on mobility and examples of common or potential constituents of concern, are described in the following text. A complete list of solid LLW constituents by K_d is provided in Volume II, Appendix G. The constituent mobility classes used for modeling include:

- **Mobility Class 1** – Contaminants were modeled as non-sorbing (that is, $K_d = 0$) and would not be retarded in the soil-water system. Contaminant K_d values in this group are within the range of 0 to 0.59 mL/g and include all the isotopes of iodine, technetium, selenium, chlorine, and tritium.

- **Mobility Class 2** – Contaminants were modeled as slightly sorbing (that is, $K_d = 0.6$) and would be slightly retarded in the soil-water system. Contaminant K_d values in this group are within the range of 0.6 to 0.99 mL/g and include all the isotopes of uranium and carbon.

- **Mobility Class 3** – Contaminants were modeled as slightly more sorbing (that is, $K_d = 1$). Contaminant K_d values in this group are within the range of 1.0 to 9.9 mL/g and include all the isotopes of barium.

- **Mobility Class 4** – Contaminants were modeled as moderately sorbing (that is, $K_d = 10$). Contaminant K_d values in this group are within the range of 10 to 39.9 mL/g and include all the isotopes of neptunium, palladium, protactinium, radium, and strontium.

- **Mobility Class 5** – Contaminants were modeled as strongly sorbing (that is, $K_d = 40$). Contaminant K_d values in this group are 40 mL/g or greater and include all the isotopes of actinium, americium, cobalt, curium, cesium, iron, europium, gallium, niobium, nickel, lead, plutonium, samarium, tin, thorium, and zirconium.

Estimated inventories of hazardous chemical constituents associated with LLW and MLLW disposed of after 1988 being considered under each alternative group would be expected to be found at trace levels. MLLW, which would be expected to contain the majority of hazardous chemical constituents, would undergo predisposal solidification to stabilize waste forms and containment and thermal treatment to remove organic chemical components of the MLLW. This waste treatment would be done to meet current waste acceptance criteria and land disposal restrictions before being disposed of in permitted MLLW facilities. Consequently, potential groundwater quality impacts from these constituents would not be expected to be substantial.

Analysis of MLLW inventories for this assessment did identify two exceptions that included lead and mercury inventories associated with the projected MLLW that were estimated at 336 kg (741 lb) and 2.5 kg (5.5 lb), respectively. Because of its affinity to be sorbed into Hanford sediments, lead falls within Mobility Class 5 ($K_d = 40$ mL/g) and would not release to groundwater within the 10,000-year period of interest. The inventory estimated for mercury is assumed to be small enough that it would not release to groundwater in substantial concentrations. Even the most conservative estimates of release would yield estimated groundwater concentrations at levels of two orders of magnitude below the current drinking water standard for mercury of 0.002 mg/L.

LLW disposed of prior to October 1987 may contain hazardous chemical constituents, but no specific requirements existed to account for or report the content of hazardous chemical constituents in this category of LLW. As a consequence, analysis of these constituents and estimated impacts based on the limited amount of information on estimated inventories and waste disposal locations would be subject to uncertainty at this time. (Additional discussion on uncertainties is presented in Section 3.5.) These facilities are part of the LLW and MLLW facilities in the LLW management Areas (LLWMAs) 1 through 4 that currently are being monitored under RCRA interim status programs. Final closure or remedial investigation of these facilities under RCRA (42 USC 6901) and/or CERCLA (42 USC 9601) guidelines could involve further analysis of the potential impacts of the chemical components of these inventories.

In response to comments received during the public comment periods on the drafts of the HSW EIS, efforts were made to develop an estimate of quantities of potentially hazardous chemicals in previously buried LLW so that an initial analysis of potential impacts of such chemicals on groundwater quality could be evaluated. The estimation of these inventories, which used a waste stream analysis estimation method, is summarized in the Technical Information Document (FH 2004). This initial assessment of the estimated hazardous chemical inventory in pre-1988 buried wastes is provided in Section 5.3.7 and Section G.6 in Volume II, Appendix G.

The source term is the quantification of when and which constituents (by mass or activity) would be released. This source term includes the water flux into the vadose zone that results from precipitation infiltrating the waste and mass or activity solubilized from dissolution of waste in the HSW disposal facilities. A detailed description of the source term and the rates of release of constituents into the groundwater can be found in Volume II, Appendix G. Methods used for calculating source release and transport of constituents in the vadose zone and groundwater also are described in Volume II, Appendix G.

5.3.2.1 Previously Disposed of Waste and Category 1 Low-Level Waste

Previously disposed of LLW and Cat 1 LLW were evaluated using similar modeling approaches. Previously disposed of LLW consists of waste emplaced in the HSW disposal facilities from 1962 to 1970 and between 1970 and 1987; Cat 1 LLW consists of waste emplaced since 1988 and forecasted to be emplaced in the future in the 200 East Area and the 200 West Area.

Assumptions for analysis of these LLW types include:

- All LLW would be buried by 2046. At the beginning of the analysis period, all constituents of concern were assumed to be available for transport via infiltrating precipitation to the vadose zone and for eventual arrival at the groundwater.

- The start of release is variable and dependent on the waste category. Because of uncertainties in the use of waste containers and containment prior to 1995, releases for the pre-1970 LLW, 1970-1987 LLW, and 1988–1995 LLW were conservatively approximated by initiating waste releases in 1966, 1976, and 1996, respectively. Since 1995, the use of more robust waste containment and waste forms (that is, the use of steel drums and steel boxes for Cat 1 LLW and the use of macroencapsulated grouting and high-integrity containers for Cat 3 LLW) has become a standard practice. Thus the start of release of all LLW and MLLW disposed of after 1995 was assumed to be delayed at least until the time of site closure in 2046.

- Source-term release for the LLW was estimated using the soil-debris release model. In this model, the waste, itself, was assumed to have the same hydraulic characteristics of the surrounding soil materials. The inventory in the LLW was conservatively assumed to be immediately available for leaching and would be leached out of the HSW disposal facilities at the assumed infiltration rate.

- For all alternatives involving LLW previously disposed of before 1996, the soil-debris release model assumed an infiltration rate of 5 cm/yr during the period of operations before year 2046. This assumption of infiltration provides conservative estimates of waste release to groundwater for earlier disposals (prior to 1995) when waste containment was not as robust. This assumed release model infiltration rate was used for the pre-1970 LLW, the 1970–1988 LLW, and the 1988–1995 LLW.

- For all alternatives involving wastes disposed of after 1995, the soil-debris release model assumed sufficient waste containment to delay release until after site closure.

- For Alternative Groups A through E, all waste disposal sites were assumed to be covered with a Modified RCRA Subtitle C Cover system. To approximate the effect of the cover on waste release, the following assumed infiltration rates were used in the waste release modeling. For 500 years after site closure, an infiltration rate of 0.01 cm/yr was used to approximate the effect of cover emplacement over the wastes and its potential impact on reducing infiltration. After 500 years, it was assumed that the cover would begin to degrade. Between 500 and 1000 years after site closure, infiltration rates were increased from 0.01 cm/yr to 0.5 cm/yr to approximate a 500-year period of cover degradation and return to an infiltration rate reflective of natural vegetated surface soil conditions over the wastes. The final rate of 0.5 cm/yr was used for the remaining 9,000-year period of analysis. For the No Action Alternative, the release modeling from these wastes used an infiltration rate of 0.5 cm/yr, which was assumed to be an appropriate infiltration rate for naturally vegetated surface soil conditions that would persist under this alternative after site closure.

Additional analyses were performed to provide perspective on potential impacts using two additional assumptions: 1) no cover system is installed and 2) a cover system is used and remains intact for the entire period of analysis (see Section 5.3.5.).

- A specific case of leaching was used to estimate the release of uranium from the LLW. For uranium, the release was controlled at a solubility limit of 64 mg/L, a conservative estimate of uranium solubility at Hanford estimated by Wood et al. (1995) for LLW in the 200 West Area.

- During the post-closure period (that is, after 2046), the infiltration rate used for vadose zone flow was assumed to be 0.5 cm/yr to reflect natural recharge in the surrounding environment of naturally vegetated surface soil conditions. In the absence of artificial recharge, vadose simulation results based on this assumed infiltration rate indicated a travel time to the water table of about 560 years in the 200 East Area and 900 years in the 200 West Area.

- The thickness of the LLW was assumed to be 6 m (20 ft) for disposal in the existing trenches and 15.6 m (51 ft) for the enhanced design waste trenches (deeper, wider trenches in Alternative Group A; single expandable trenches in Alternative Group C; and in the lined modular facility in Alternative Groups D_1, D_2, D_3, E_1, E_2, and E_3).

- For a number of the alternative groups, the analysis considered the use of liner systems to control waste release during the period of operations. However, no specific credit for the effect of these liner systems was considered in this long-term analysis. Although the liner systems, as described in Section 3.1, might last (contain leachate for removal) for several hundreds of years if properly managed, this analysis assumed that the emplaced liners would fail during the 100-year active institutional control period and would have little effect on the long-term waste release during the 10,000-year period of analysis.

5.3.2.2 Cat 3 Low-Level Waste

Assumptions for analysis of Cat 3 LLW that differs from those of Cat 1 LLW follow:

- Because all Cat 3 LLW is either buried in high-integrity containers (HICs) constructed of concrete or disposed of by in-trench grouting, the calculations assumed a delay in contaminant release (the design lifetime of an individual HIC). Source-term releases of carbon-14 and iodine-129 were estimated using the soil-debris release model with the assumed delay in release to account for containment of the LLW in either HIC or in-trench grouting. In this model, the inventory in the LLW was conservatively assumed to be immediately available for leaching. The exception to this approach was technetium-99 and uranium in LLW. The technetium-99 LLW was assumed to be disposed of within the HIC in a macroencapsulated grout form, and the release of technetium-99 was assumed to be controlled by diffusion through the grout.

- The leaching of uranium disposed of in cementitious waste forms (that is, in macroencapsulated grout or HICs) was based on a solubility controlled release model that used an assumed lower uranium solubility limit of 0.2 mg/L (Wood et al. 1996). This solubility limit, which is lower than the 64 mg/L used for leaching of uranium in non-cemented wastes, is a conservative representation of uranium solubility in the alkaline geochemical conditions created by the presence of cement in the disposal environment. Additional information on recent studies of leaching of uranium from cementitious waste forms is available from Krupka and Serne (1996) and Serne et al. (1996).

5.3.2.3 Mixed Low-Level Waste

MLLW analyzed in this section includes waste emplaced since 1988 and waste forecasted to be emplaced in the future. Trenches 31 and 34 in LLBG 218-W-5 in the 200 West Area were constructed specifically for disposal of MLLW. MLLW in excess of the capacity of these trenches is assumed to be disposed of in newly constructed MLLW trenches in designated locations defined in Alternative Groups A through E.

Assumptions for analysis of MLLW that differs from those of Cat 1 LLW follow:

- Some of the MLLW would be disposed of in a matrix of macroencapsulated grout similar to Cat 3 LLW.

- The thickness of the MLLW disposed of in the 200 West Area in Trenches 31 and 34 within LLBG 218-W-5 was assumed to be 6 m (20 ft). Depth of the MLLW disposed of in the 200 East Area in the enhanced trench at other LLBG locations was assumed to be 15.6 m (51 ft).

5.3.2.4 Melters from the Waste Treatment Program

Melters analyzed in this section are forecasted to be emplaced in a new 21-m (69-ft) deep disposal facility, which would be constructed in locations designated in Alternative Groups A through E.

Assumptions for analysis of melters that differ from those of MLLW follow:

- The depth of the melter disposal facility, wherever constructed, was assumed to be 21 m (69 ft), and the waste thickness was assumed to be 18.6 m (61 ft).

- The melters were assumed to be macroencapsulated in grout. Thus, the release of inventories of constituents contained within this waste was assumed to be controlled by the presence of grout. The release of technetium-99 was assumed to be controlled by diffusion using the diffusion-controlled release model. The release of uranium isotopes was assumed to be controlled by a solubility-controlled release models using a solubility limit of 0.2 mg/L. (This value is used for uranium release from other waste categories that use cementitious waste forms.) All of these waste release assumptions would represent a conservative treatment of waste release for these melters since constituents contained within these wastes would be contained in thick heavy gauge steel and encapsulated and incorporated in a vitrified waste mass and would likely be controlled by a much lower release rate related to steel corrosion and glass degradation.

5.3.3 Use of ILAW Performance Assessment Calculations to Support the HSW EIS

Potential impact results presented for ILAW disposal in this assessment were not based on independent calculations used in the previously described methodology, but rather on recent performance assessment (PA) calculations made for siting the ILAW HSW in the vicinity of the PUREX Plant, as summarized in Mann et al. (2001).

Under Alternative Groups A, C, D_1, and E_3, where ILAW disposal is sited near the PUREX facility, results of a sensitivity case in Mann et al. (2001) that analyzed the effect of 25,550 Ci of technetium-99 was used. This case reflected no technetium-99 removal from low-activity waste in the separation processes from the Waste Treatment Plant.

In this analysis, the results for the ILAW were superimposed directly onto the results of other waste categories calculated for this analysis at the operational area (the 200 East and West Areas and ERDF) and Columbia River LOAs, as appropriate for each alternative group. Thus where ILAW may be disposed of near the PUREX Plant (Alternative Groups A, C, D_1, and E_3), ILAW results were superimposed onto other potential waste category impacts at the 200 East Area SE LOA. Where ILAW is disposed of in the 200 East Area LLBGs (Alternative Group D_2), ILAW results were superimposed onto other potential waste category impacts at the 200 East Area SE LOA.

For purposes of this analysis, water quality and associated human health impact results presented in Section 5.11 and Volume II, Appendix F for Alternative Group B (where the ILAW disposal facility is sited in an area south of the CWC) and Alternative Groups D_3, E_1, and E_2 (where the ILAW disposal facility is sited at ERDF) are based on simple scaling of comparative simulation results of source releases in these areas using the sitewide groundwater flow and transport model (see Section G.3.3.2 in Appendix G, Volume II). Groundwater concentrations and results of human health impacts summarized in the original performance assessment calculations described in Mann et al. (2001) were based on well intercept factors (WIFs) or dilution factors from a given areal flux of a hypothetical contaminant released to the unconfined aquifer from the ILAW disposal facility (Bergeron and Wurstner 2000). The WIF is defined as the ratio of the concentration at a well location in the aquifer to the concentration of infiltrating water entering the aquifer. These WIFs are being used in conjunction with calculations of released contaminant fluxes through the vadose zone to estimate potential impacts from radiological and hazardous chemical contaminants within the ILAW disposal facility at LOAs.

Results of applying WIFs for the three postulated ILAW disposal locations (see Section 3.3.2 in Appendix G, Volume II) suggest that predicted groundwater concentrations would be a factor of about 3 higher at the 1-km (0.6-mi) LOA downgradient of the HSW disposal site locations (south of CWC and at

ERDF) relative to a comparable location downgradient from the PUREX location. These higher-predicted concentrations would be consistent with differences in hydrogeology at these two locations relative to conditions found near the PUREX Plant. Near the PUREX Plant, the upper part of the unconfined aquifer is largely composed of very permeable sediments associated with the Hanford formation. Whereas, at the ERDF and CWC locations, the upper part of the unconfined aquifer is made up of less permeable sand and gravel sediments associated with the Ringold sediments.

These scaling factors would apply for both the Lower Bound and Upper Bound waste volumes since the ILAW volume and inventory is assumed to be the same for both cases. Peak concentrations estimated near the Columbia River from these alternative locations of disposal would be about 20 and 10 percent lower, respectively, than was calculated from releases near the PUREX location. The reductions in concentrations levels would be consistent with the longer flow path to the Columbia River.

The methods used to adapt the PA results to the analysis in the HSW EIS are provided in Volume II, Appendix G, Section G.3.

The technetium-99 inventory (25,550 Ci) used in the HSW EIS is a factor of 4.4 higher than the estimated inventory (about 5,790 Ci) if technetium-99 removal occurred in the separation process. Potential groundwater impacts attributable to technetium-99 in ILAW based on the higher estimated inventory would be reduced to about 23 percent of estimated levels presented in the HSW EIS alternative groups analyses if the lower inventory were assumed.

5.3.4 Potential Long-Term Impacts on Groundwater Quality

Of the suite of LLW constituents disposed of in the HSW disposal facilities, only technetium-99 and iodine-129 in Mobility Class 1 and carbon-14 and the uranium isotopes in Mobility Class 2 were considered to be in sufficient quantity, long-lived, and mobile enough to warrant detailed analysis of potential groundwater quality impacts. Although three of the constituents in Mobility Class 1—selenium, chlorine, and tritium—are considered to be very mobile, they were excluded from analysis because the total inventories for selenium and chlorine were considered negligible (less than 1×10^{-2} Ci); tritium was excluded because it has a relatively short half-life and would reach the groundwater from the HSW disposal facilities in very small quantities.

Estimates of transport times of constituents in Mobility Classes 3, 4, and 5 indicated their release through the thick vadose zone to the unconfined aquifer beneath the HSW disposal facilities would be beyond the 10,000-year period of analysis. Thus all constituents in these mobility classes were eliminated from further analysis.

Federal drinking water standards are used as benchmarks against which potential contamination levels may be compared. For the contaminants of interest, the Federal Drinking Water Standards (40 CFR 141.16) are based on EPA's calculated dose equivalent of 4 mrem/yr to the maximally exposed internal organ or total body. Effective December 8, 2003, however, the uranium standard is 30 μg/L, based on chemical toxicity that is more restrictive than the radiological dose standard (65 FR 76708). Drinking water standards for Washington state are stated in WAC 246-290. Federal standards are given in 40 CFR 141 and 40 CFR 143.

Concentrations of key constituents (primarily technetium-99 and iodine-129) for all Hanford solid waste types disposed of in the 200 Areas, at ERDF, and near the PUREX Plant for the LOAs by alternative group over 10,000 years for the Hanford Only and Upper Bound waste volumes are provided in Figures 5.3 to 5.21. These results represent the incremental potential impacts from wastes considered in this EIS (potential cumulative impacts of these wastes combined with other Hanford sources are presented in Section 5.14). For reference, benchmark maximum contaminant levels (MCLs) for technetium-99 and iodine-129 are 900 pCi/L and 1 pCi/L, respectively. Because of the variation in the location of the different waste types and category releases for a given alternative group, the estimated maximum concentrations calculated from a specific waste category release may not correspond to the same point on the LOA for every waste category and alternative group. Combined concentration levels presented in the following sections for each LOA and alternative group reflect the summation of estimated concentration levels regardless of their position on the LOA. As indicated in the following figures, most of the variation in groundwater radionuclide concentrations among the alternative groups resulted from proposed locations and configurations for new disposal facilities; differences between the Hanford Only and Upper Bound waste volumes were minimal.

Summary level discussions of potential impacts on groundwater quality for each alternative group are presented in the following sections. These discussions primarily focus on quantitative estimates of potential impacts related to releases of technetium-99 and iodine-129. Qualitative discussion of the potential impacts from carbon-14 and the uranium isotopes also is provided. Potential human health impacts are presented in Section 5.11.

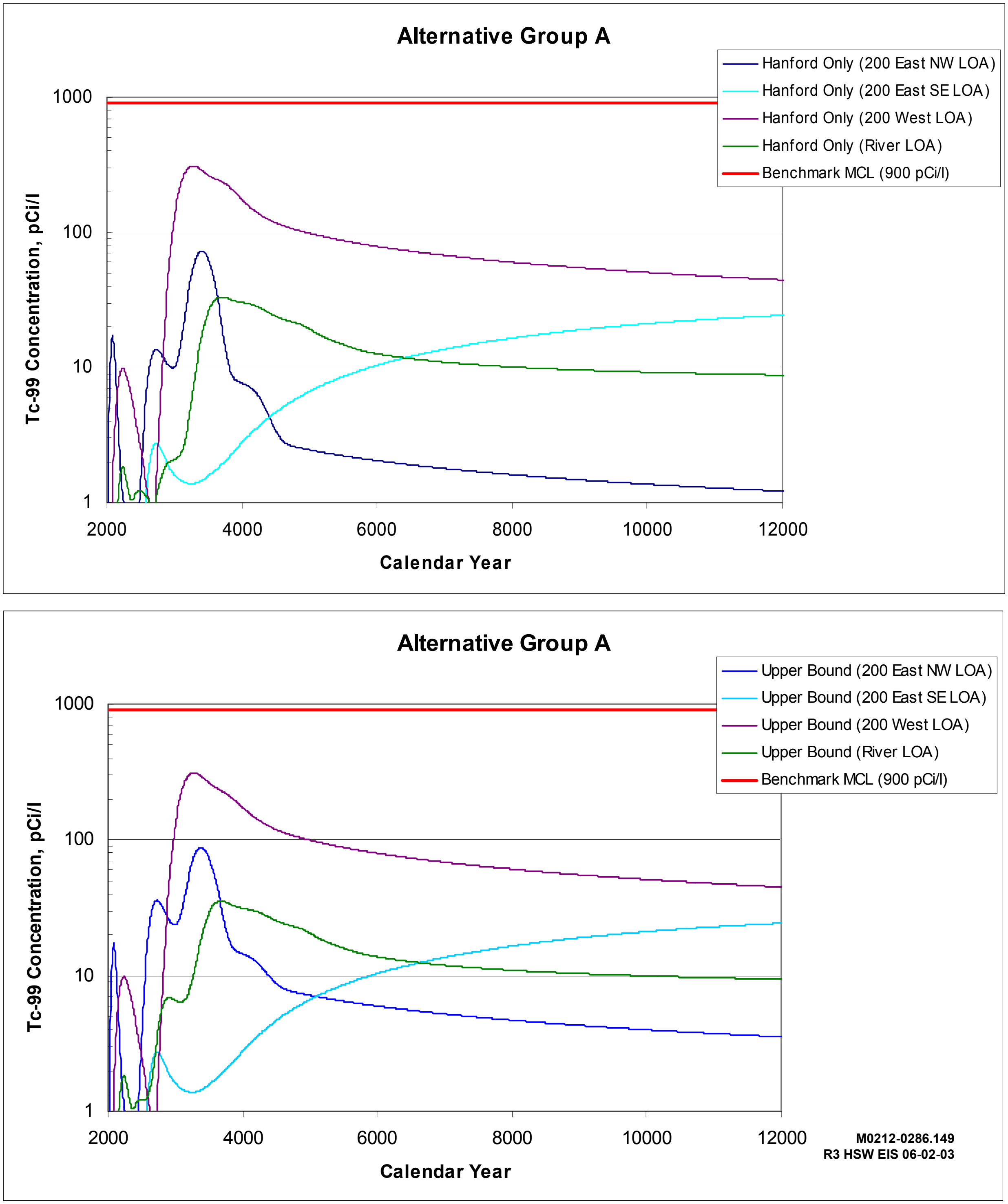


Figure 5.3. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group A – Hanford Only and Upper Bound Waste Volumes)

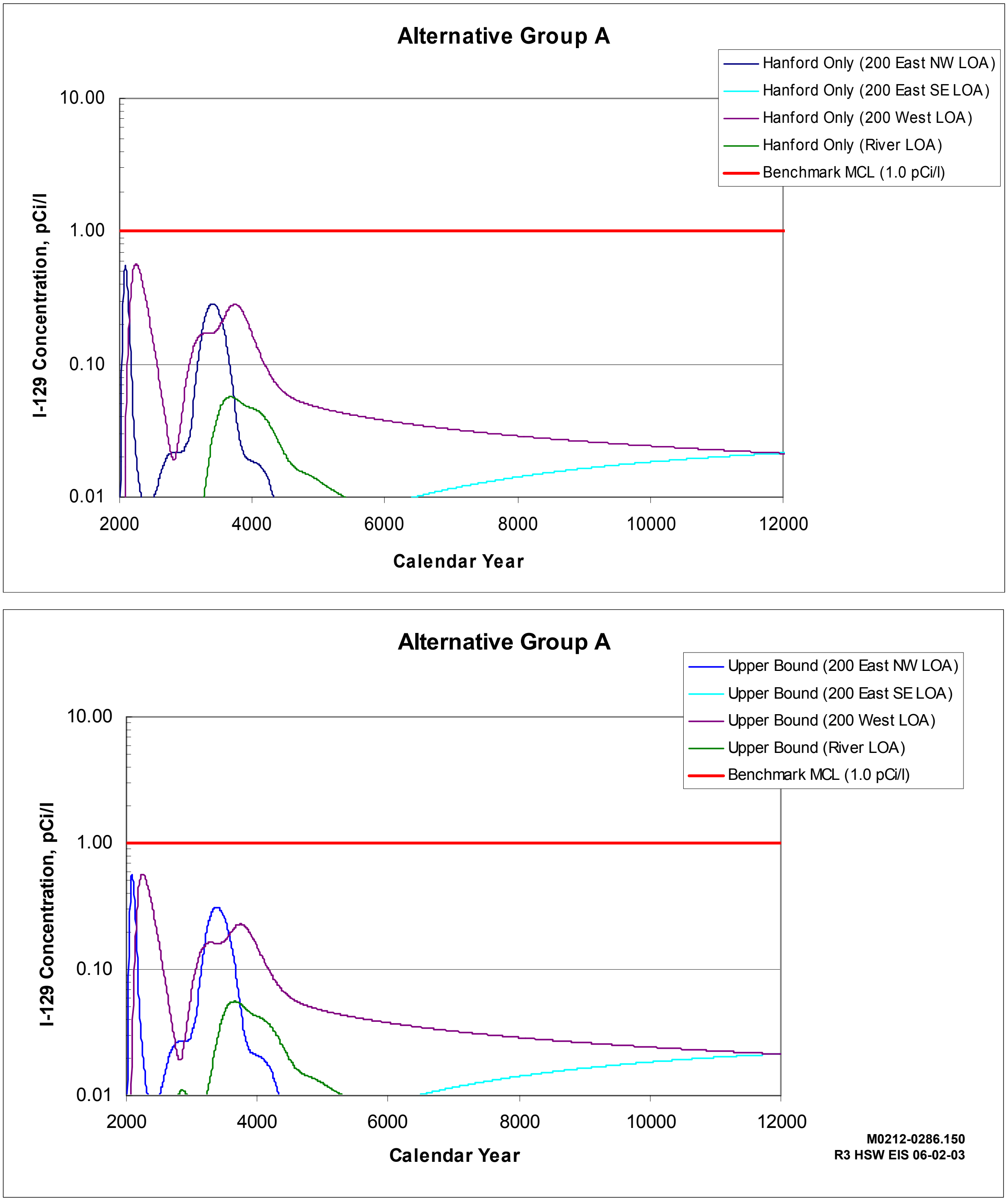


Figure 5.4. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group A – Hanford Only and Upper Bound Waste Volumes)

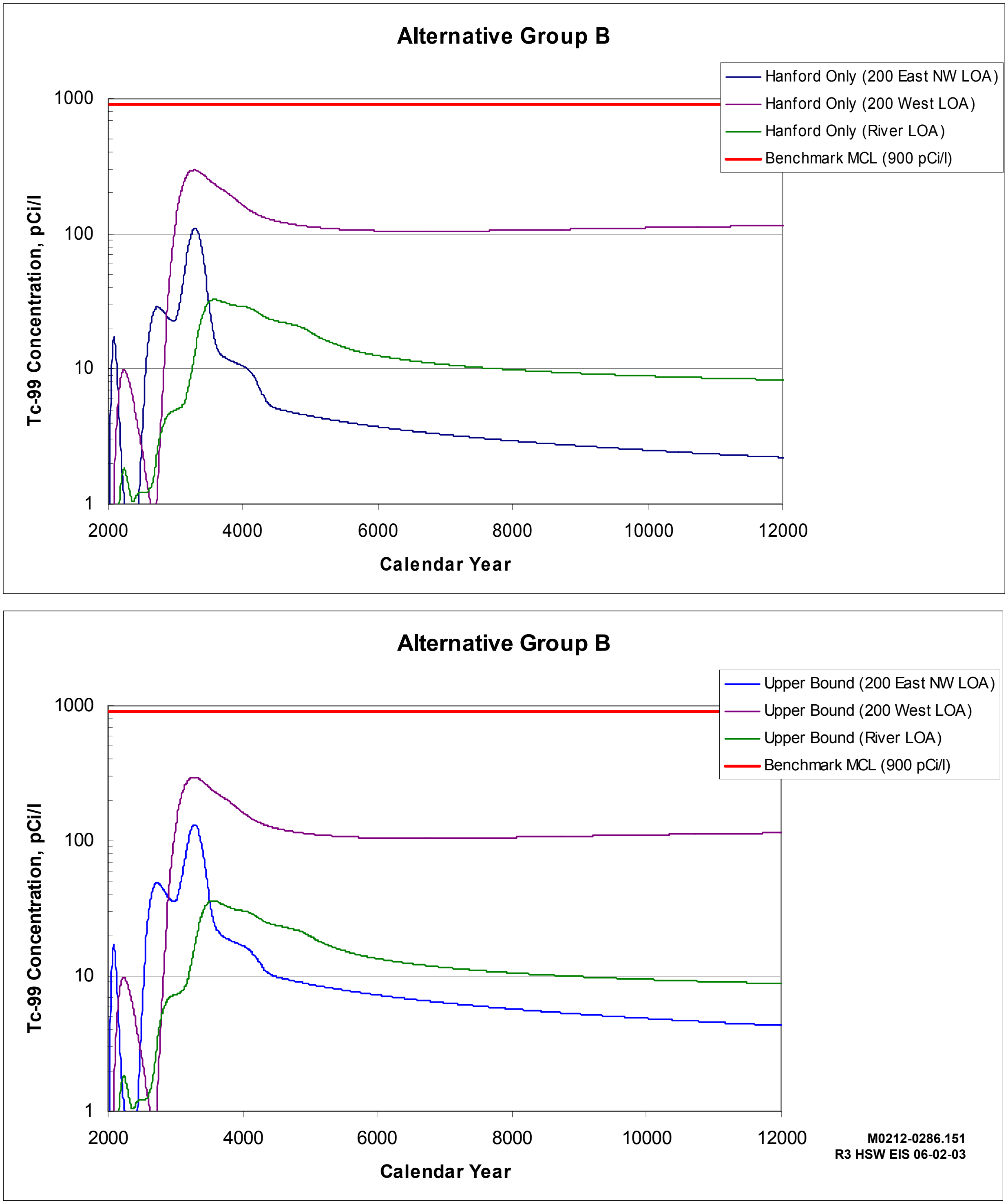


Figure 5.5. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group B – Hanford Only and Upper Bound Waste Volumes)

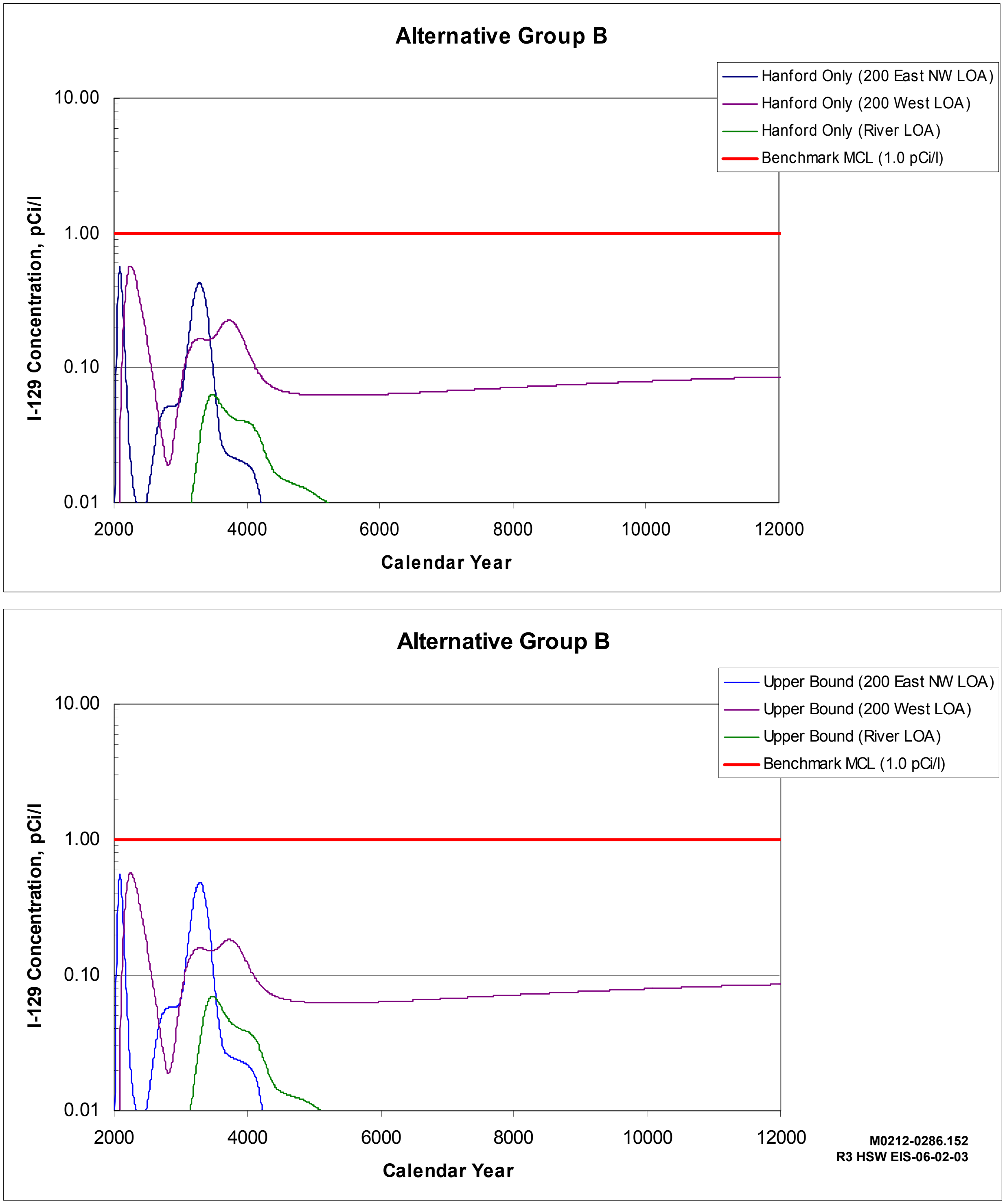


Figure 5.6. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group B – Hanford Only and Upper Bound Waste Volumes)

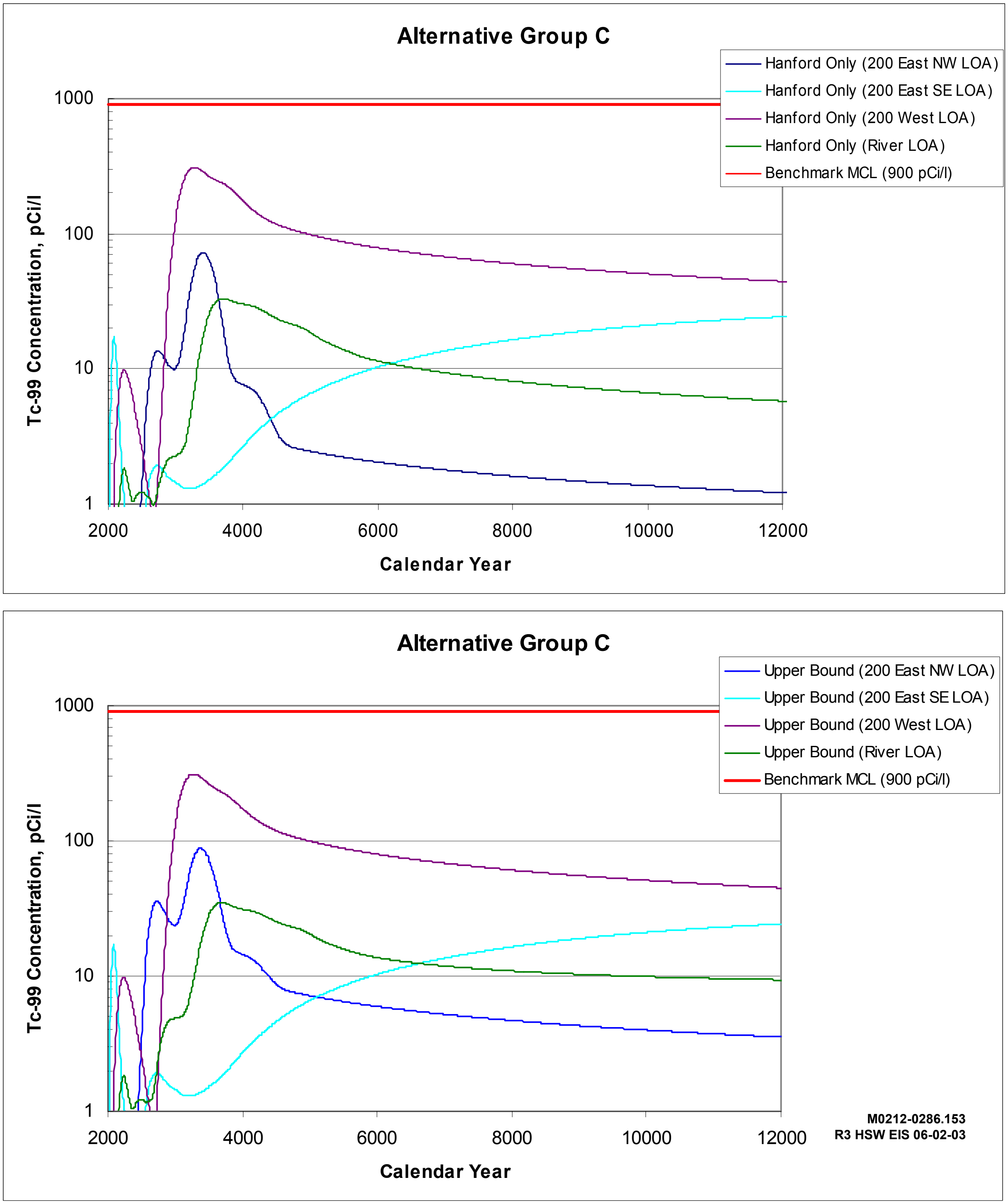
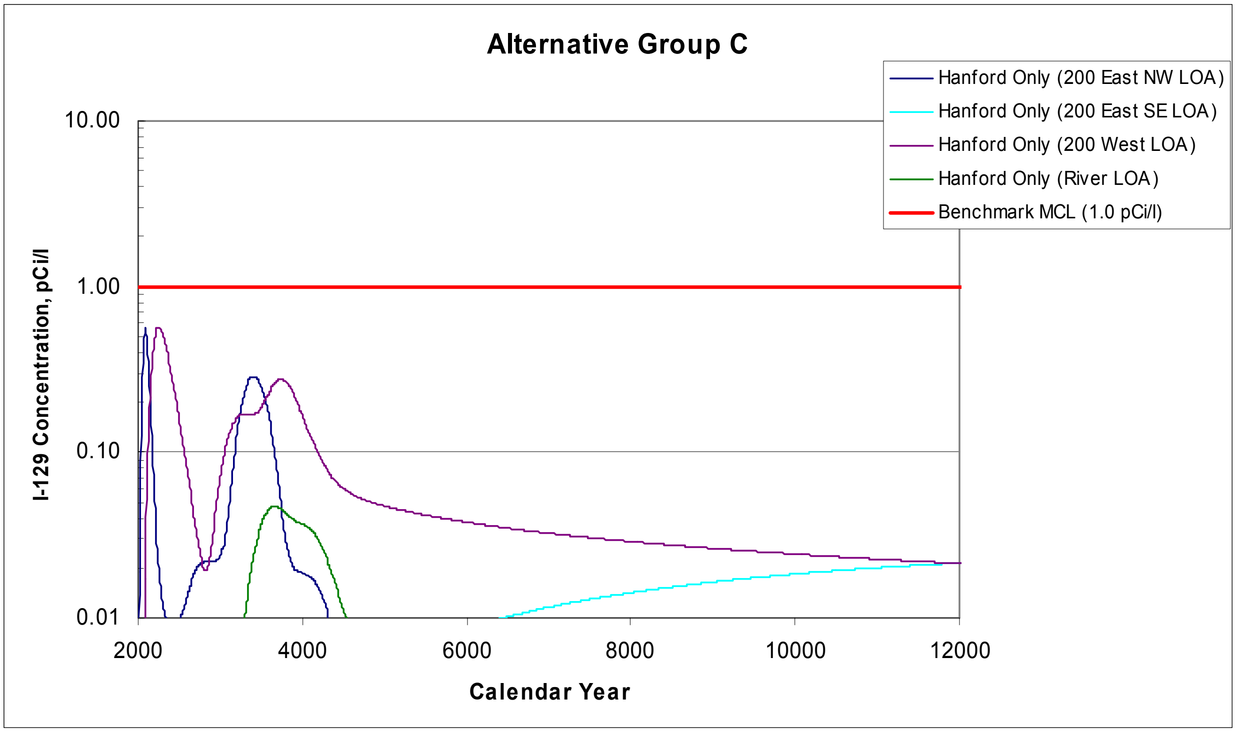


Figure 5.7. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group C – Hanford Only and Upper Bound Waste Volumes)



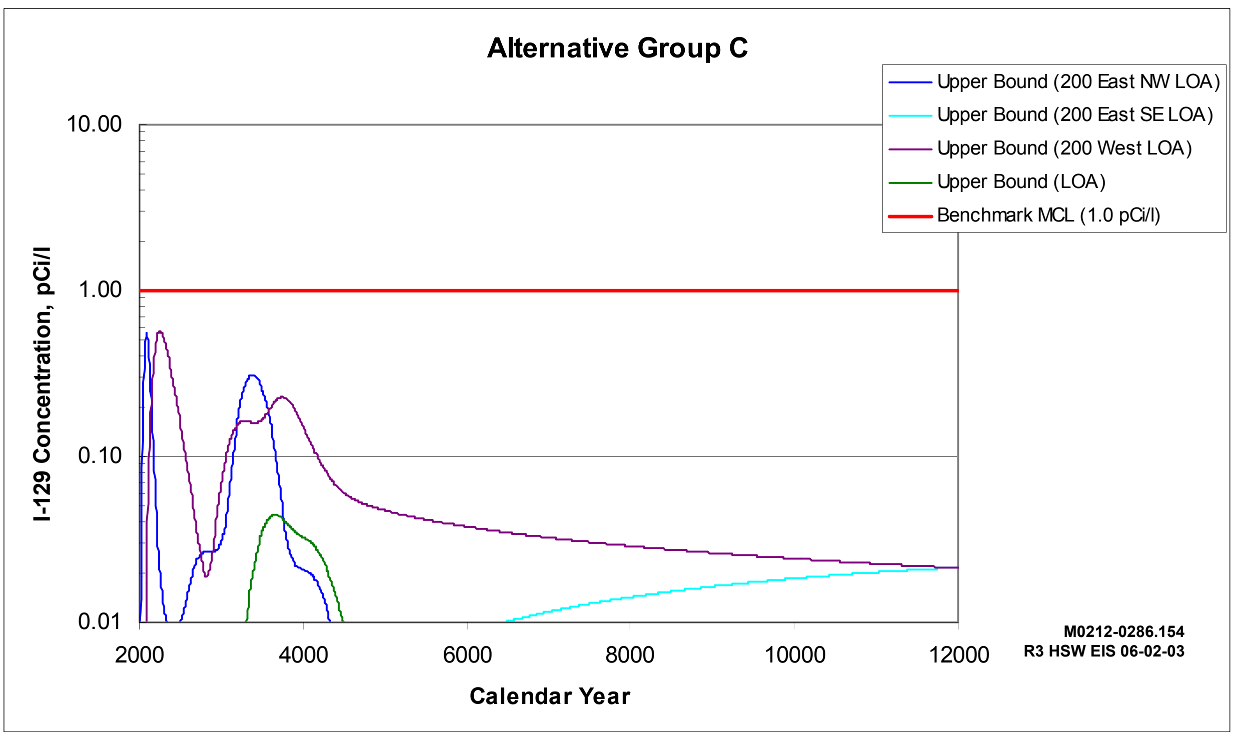


Figure 5.8. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group C – Hanford Only and Upper Bound Waste Volumes)

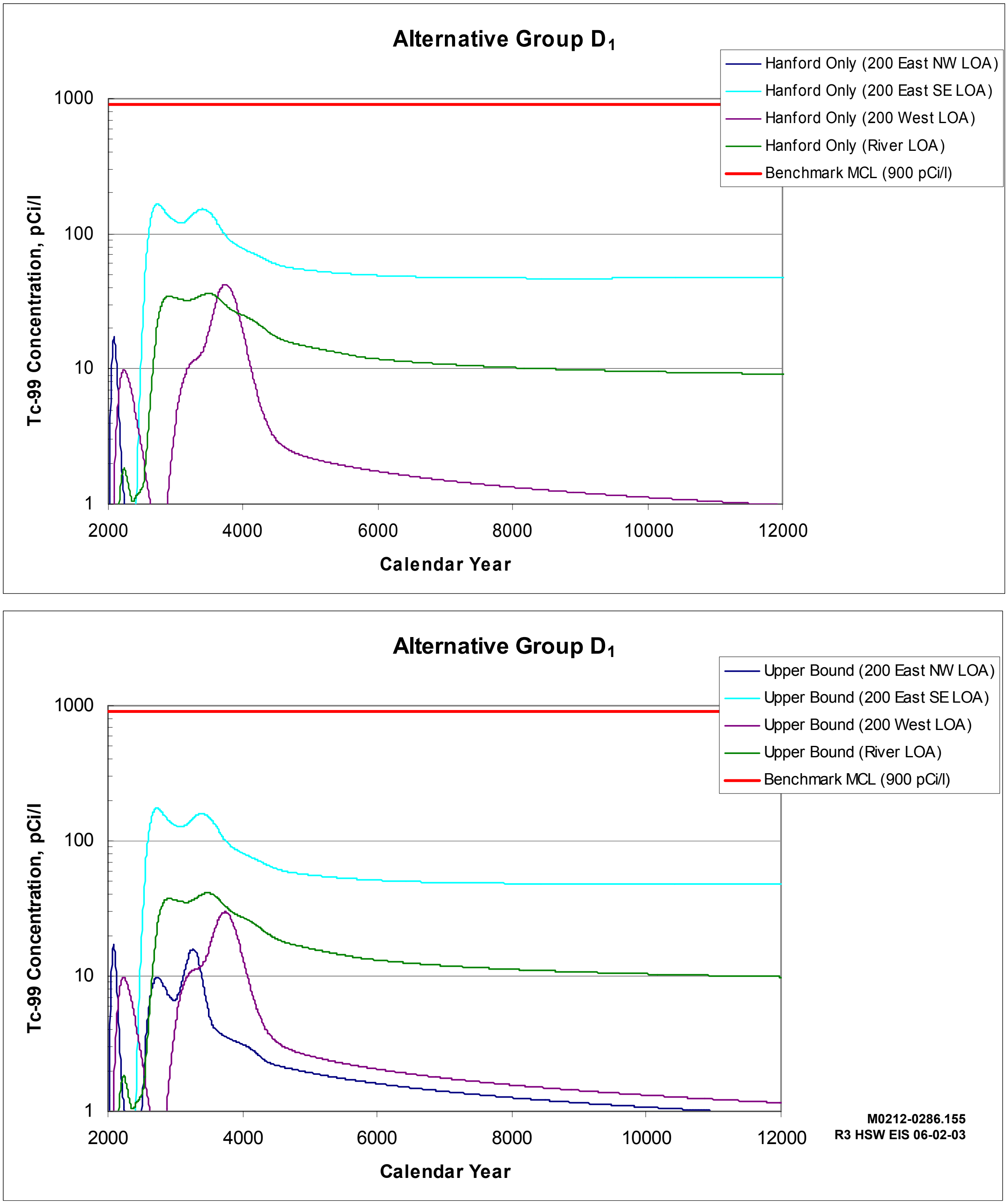


Figure 5.9. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group D_1 – Hanford Only and Upper Bound Waste Volumes)

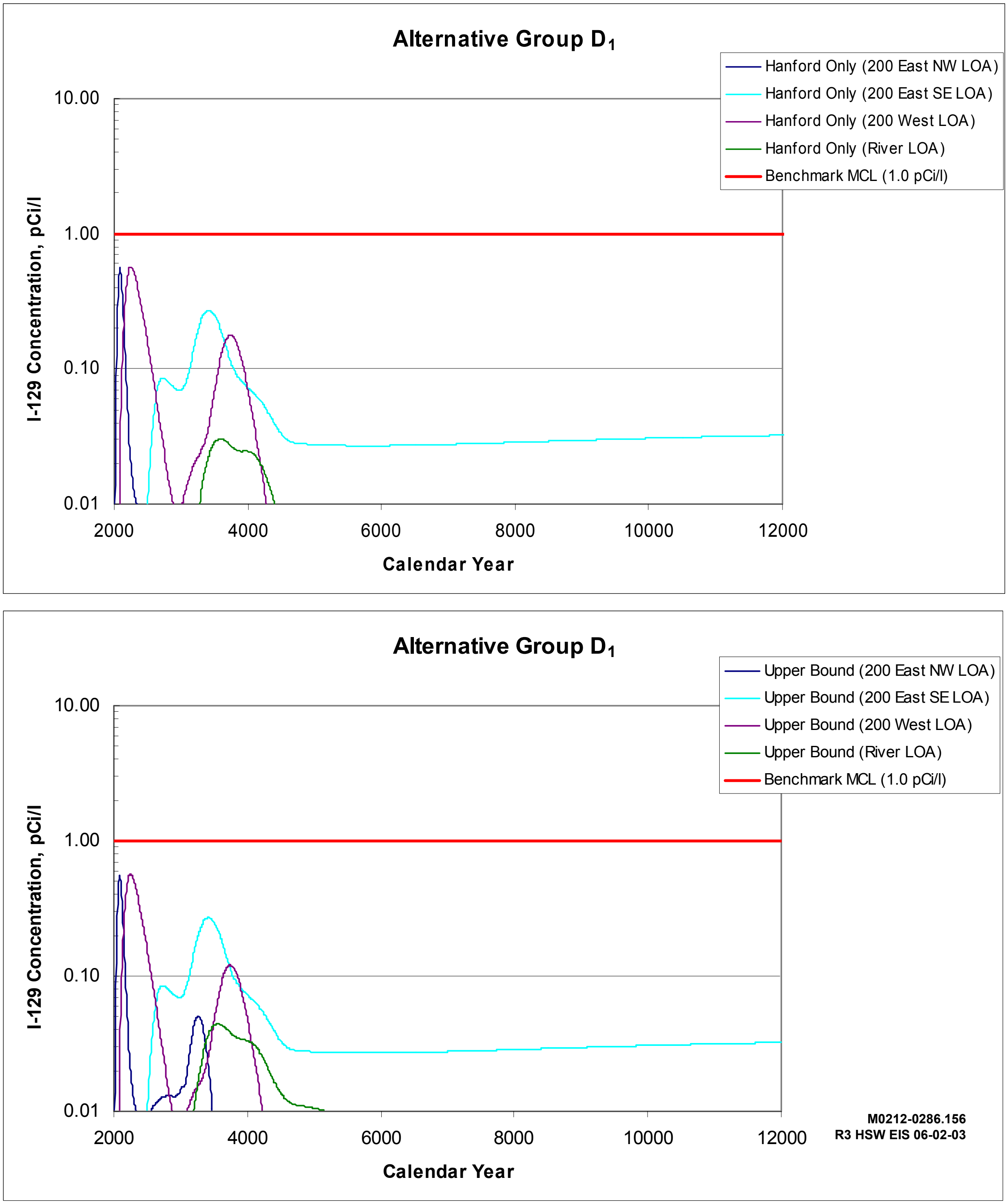


Figure 5.10. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group D_1 – Hanford Only and Upper Bound Waste Volumes)

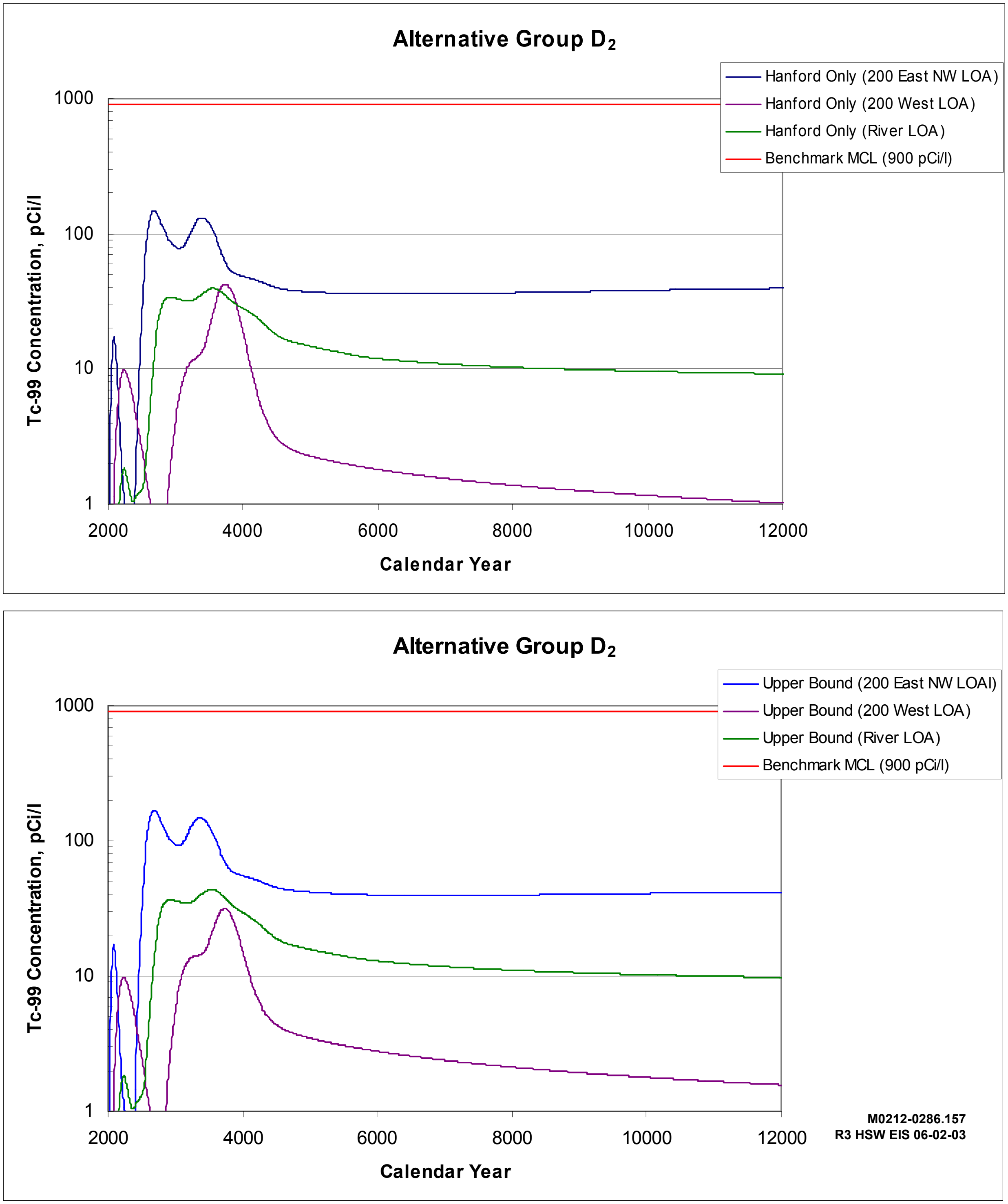


Figure 5.11. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group D_2 – Hanford Only and Upper Bound Waste Volumes)

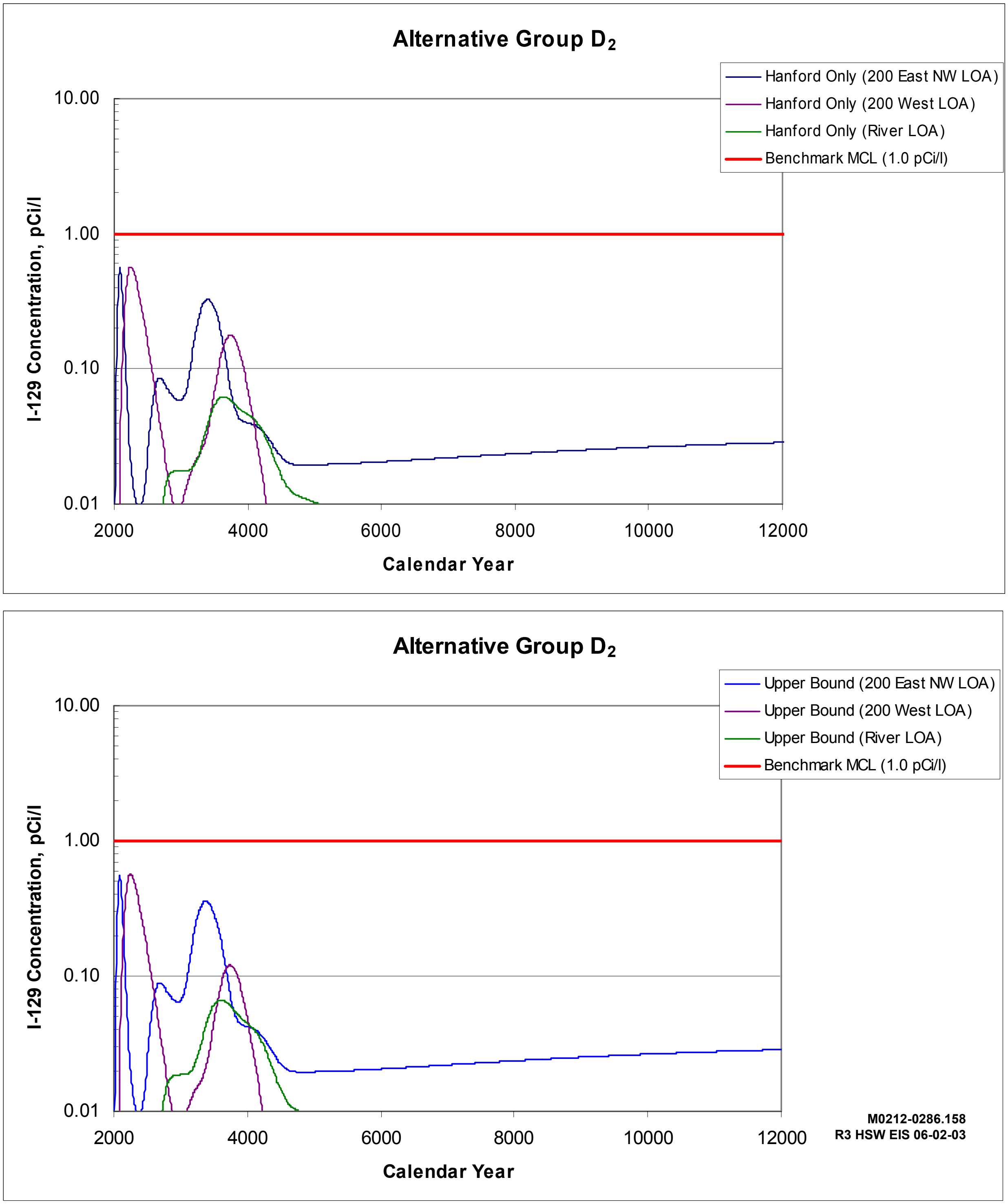


Figure 5.12. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group D_2 – Hanford Only and Upper Bound Waste Volumes)

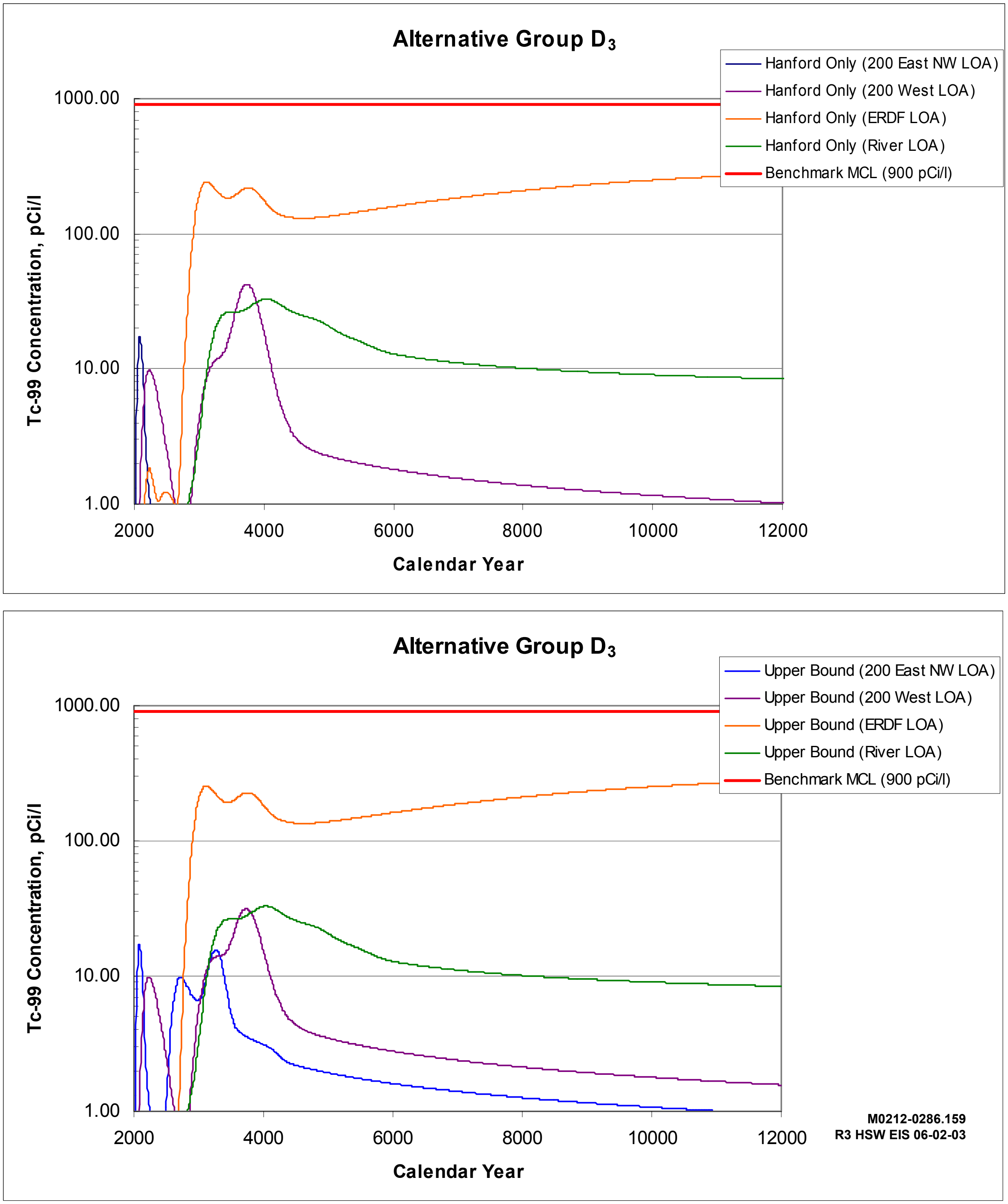


Figure 5.13. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group D_3 – Hanford Only and Upper Bound Waste Volumes)

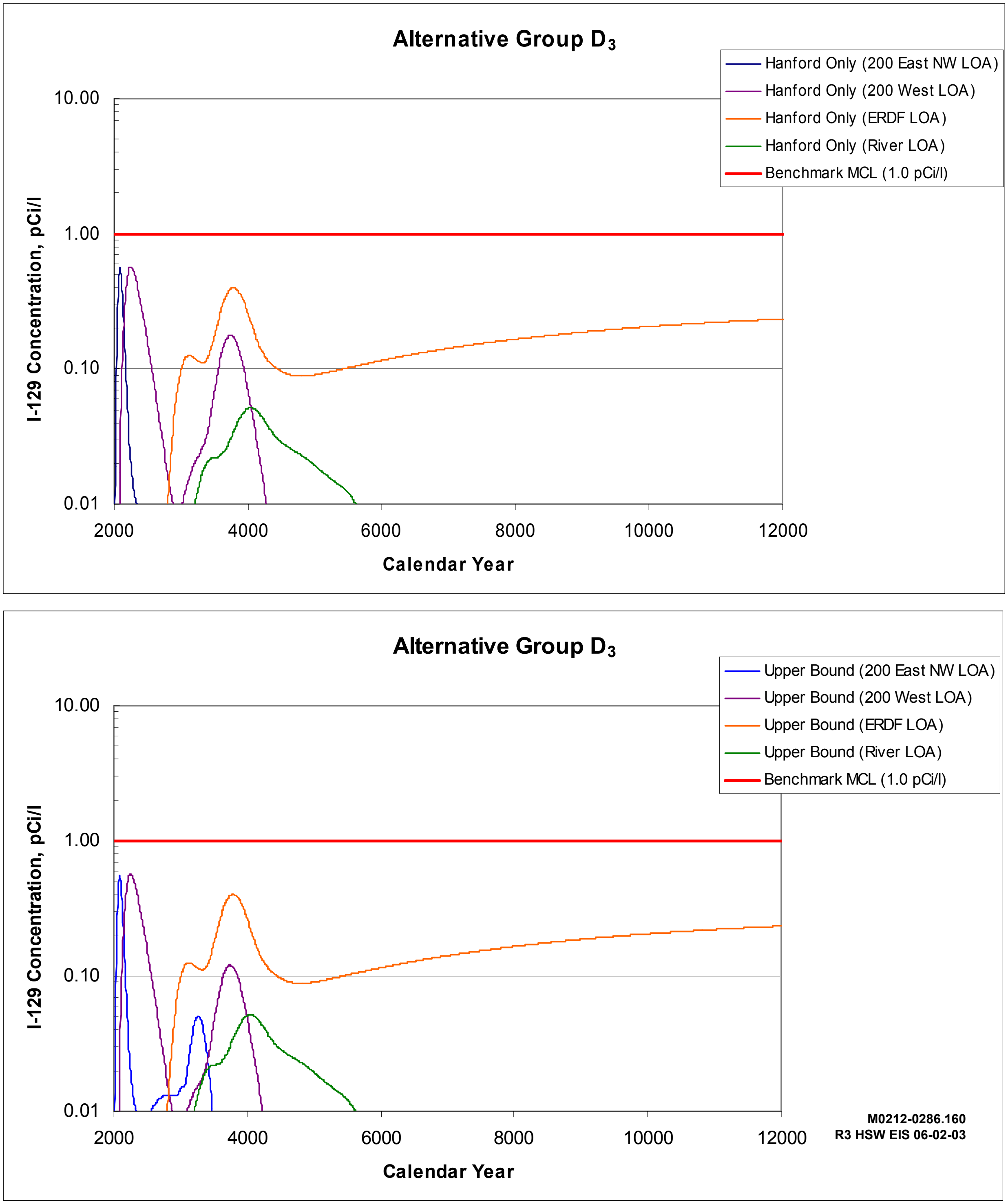
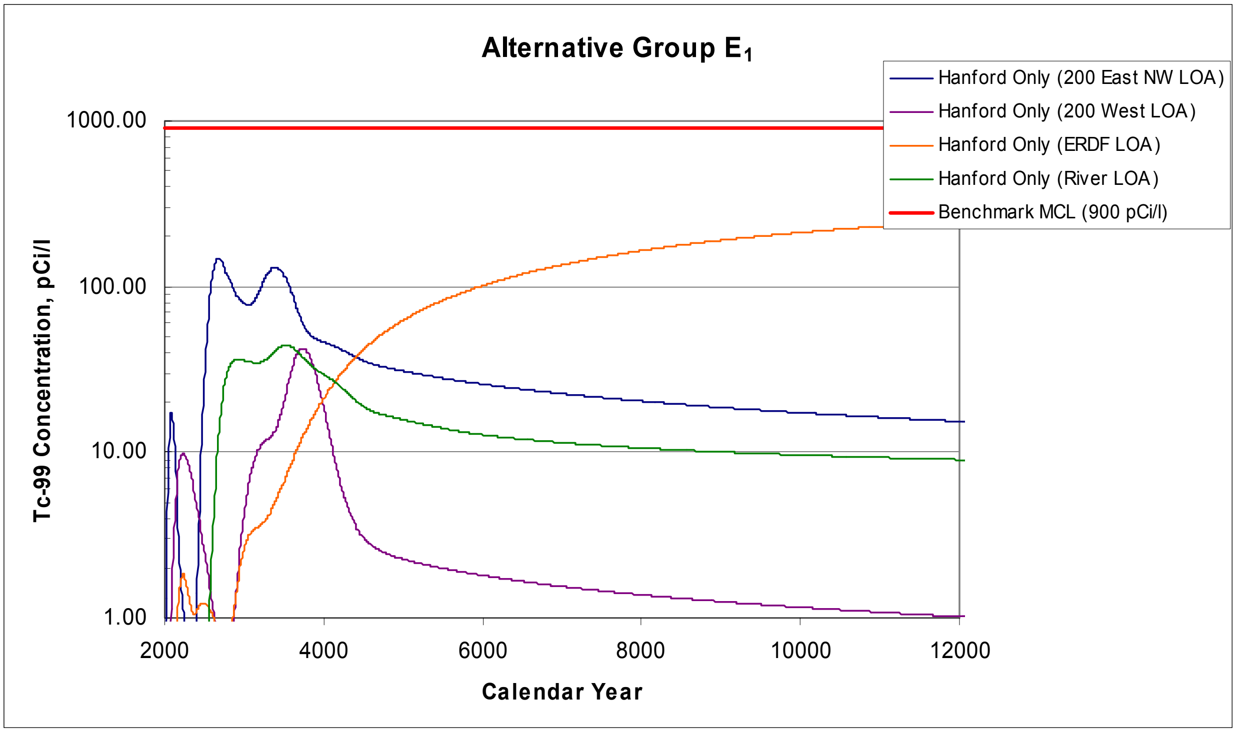


Figure 5.14. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group D_3 – Hanford Only and Upper Bound Waste Volumes)



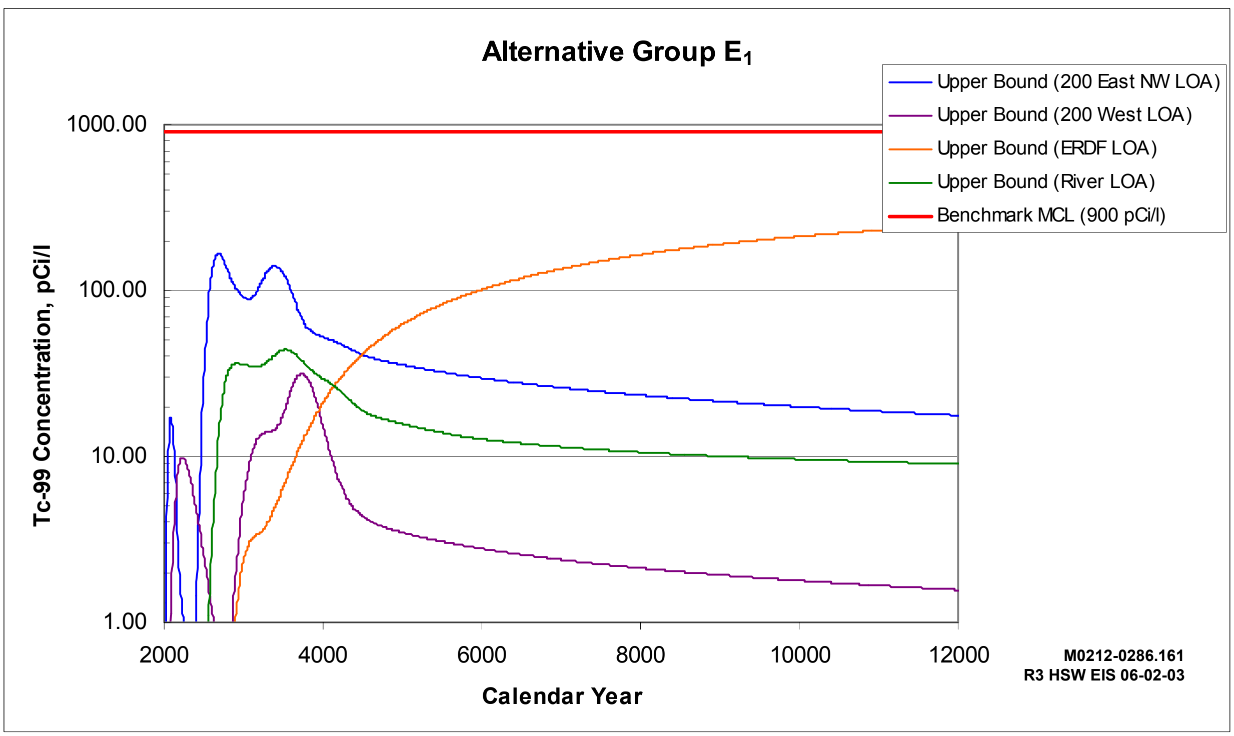
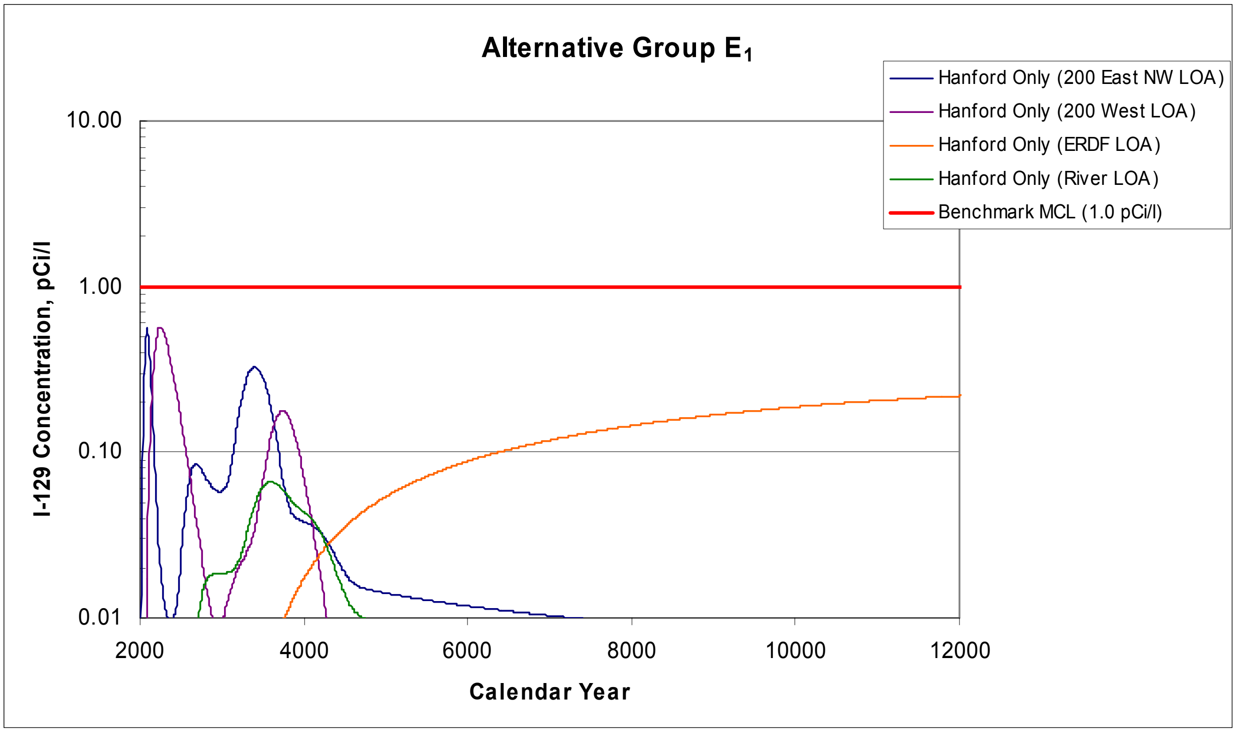


Figure 5.15. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group E_1 – Hanford Only and Upper Bound Waste Volumes)



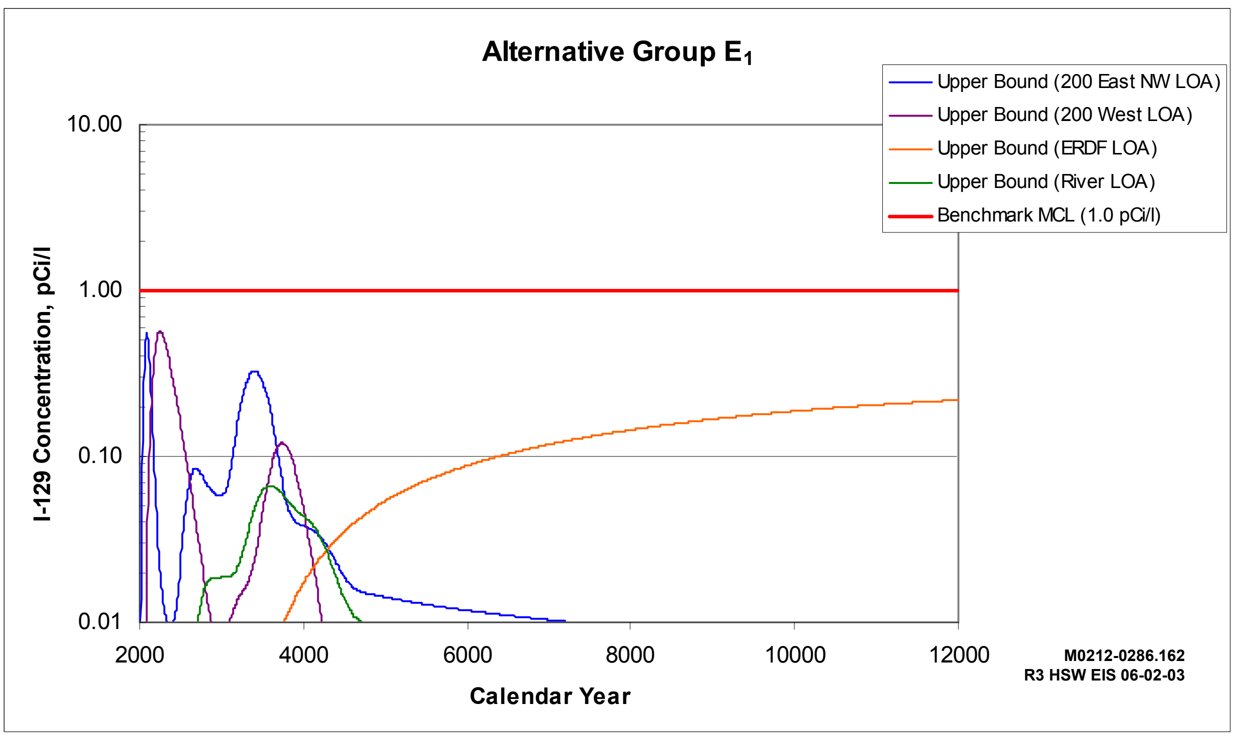
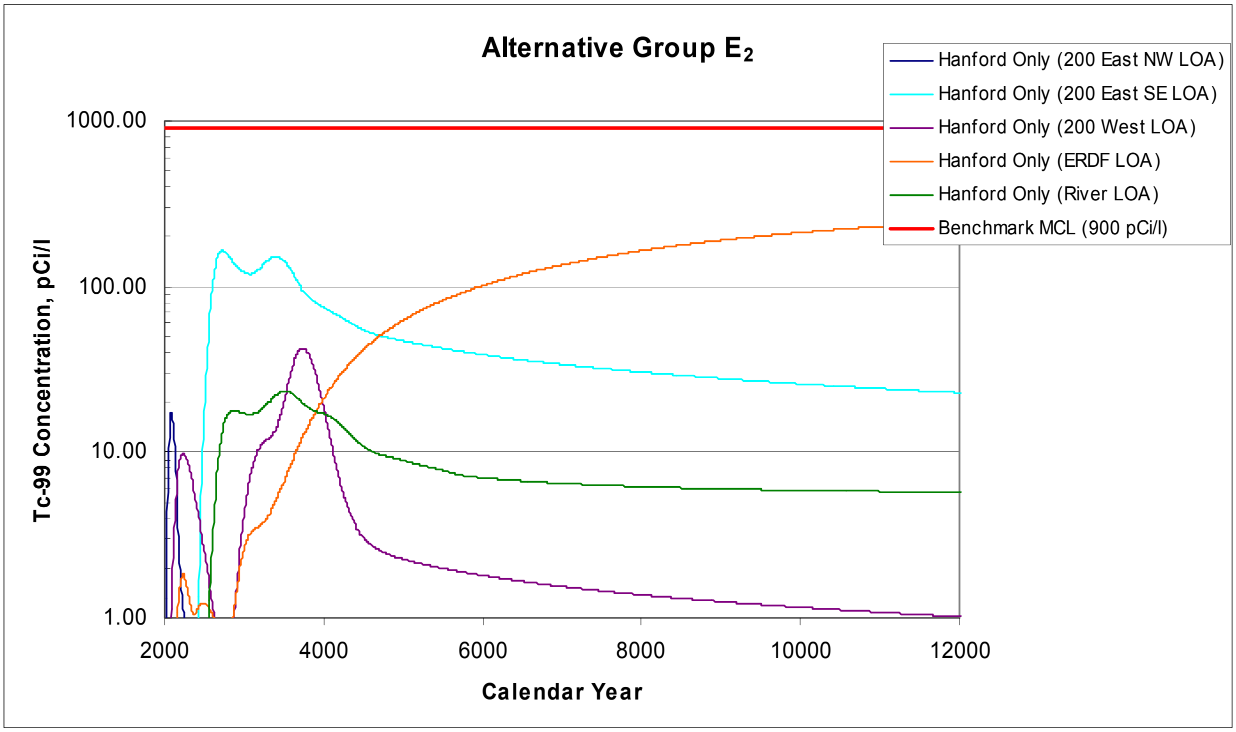


Figure 5.16. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group E_1 – Hanford Only and Upper Bound Waste Volumes)



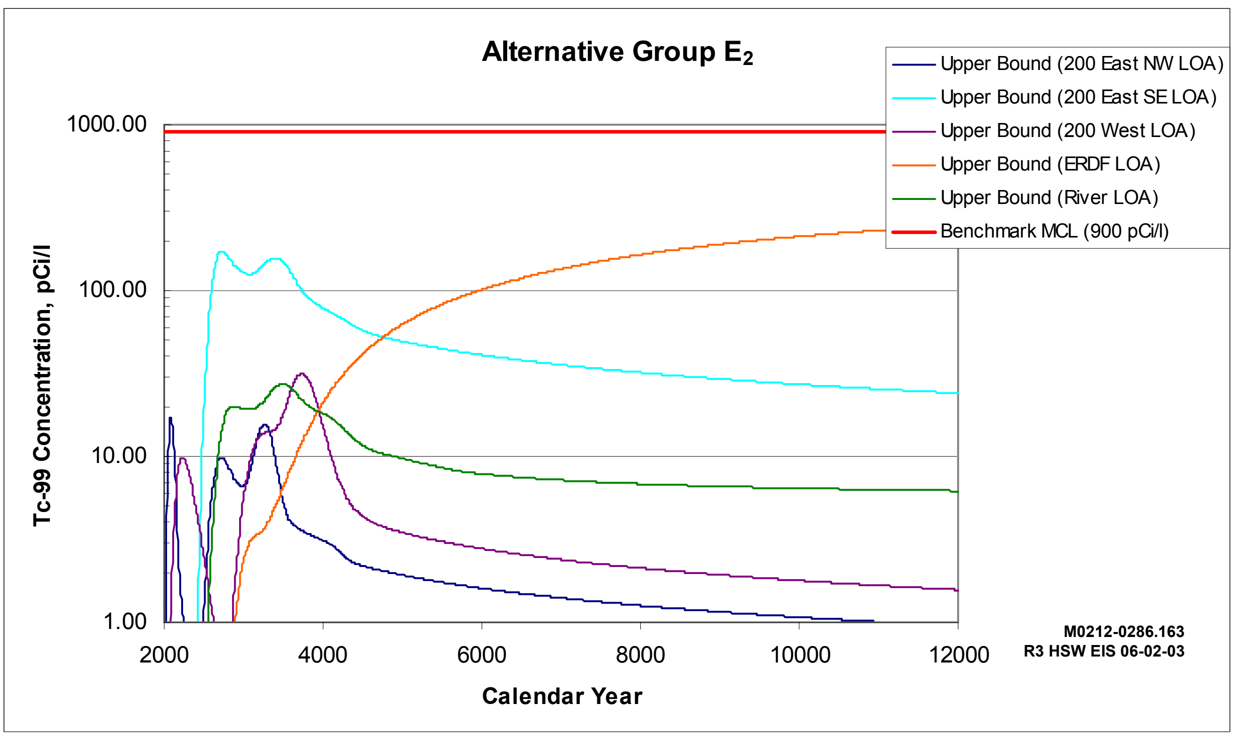
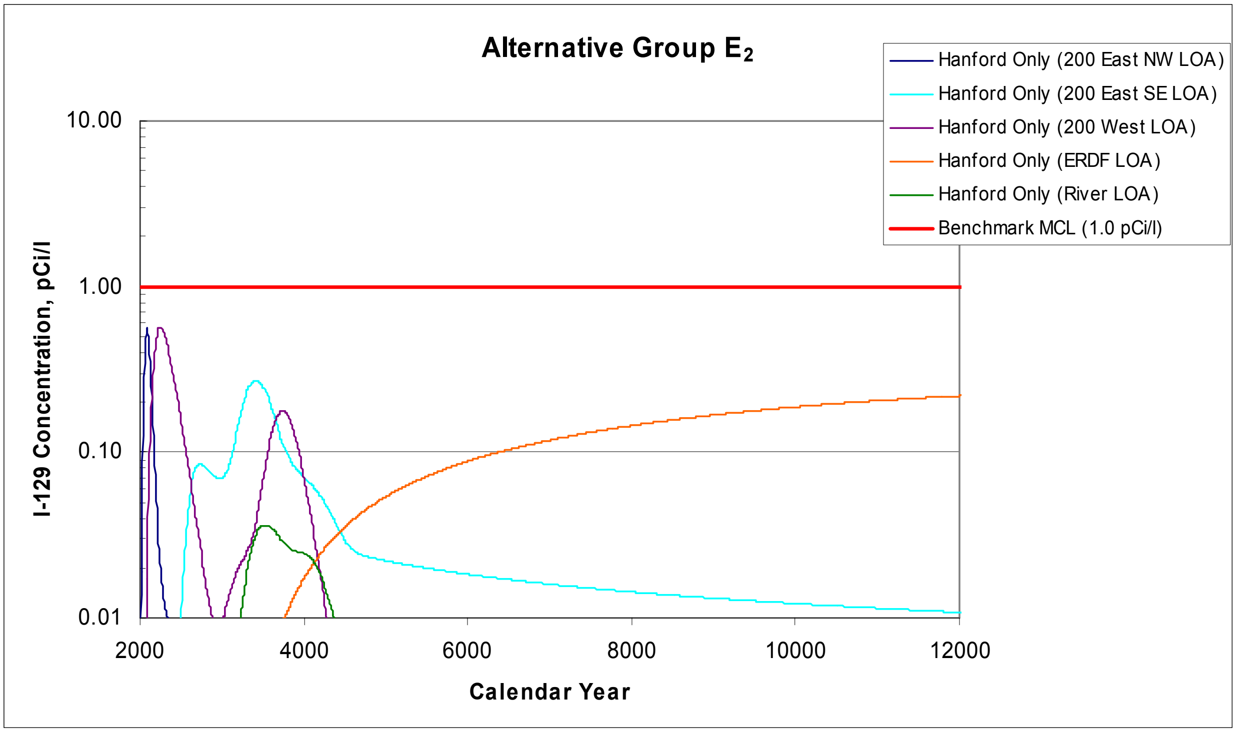


Figure 5.17. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group E_2 – Hanford Only and Upper Bound Waste Volumes)



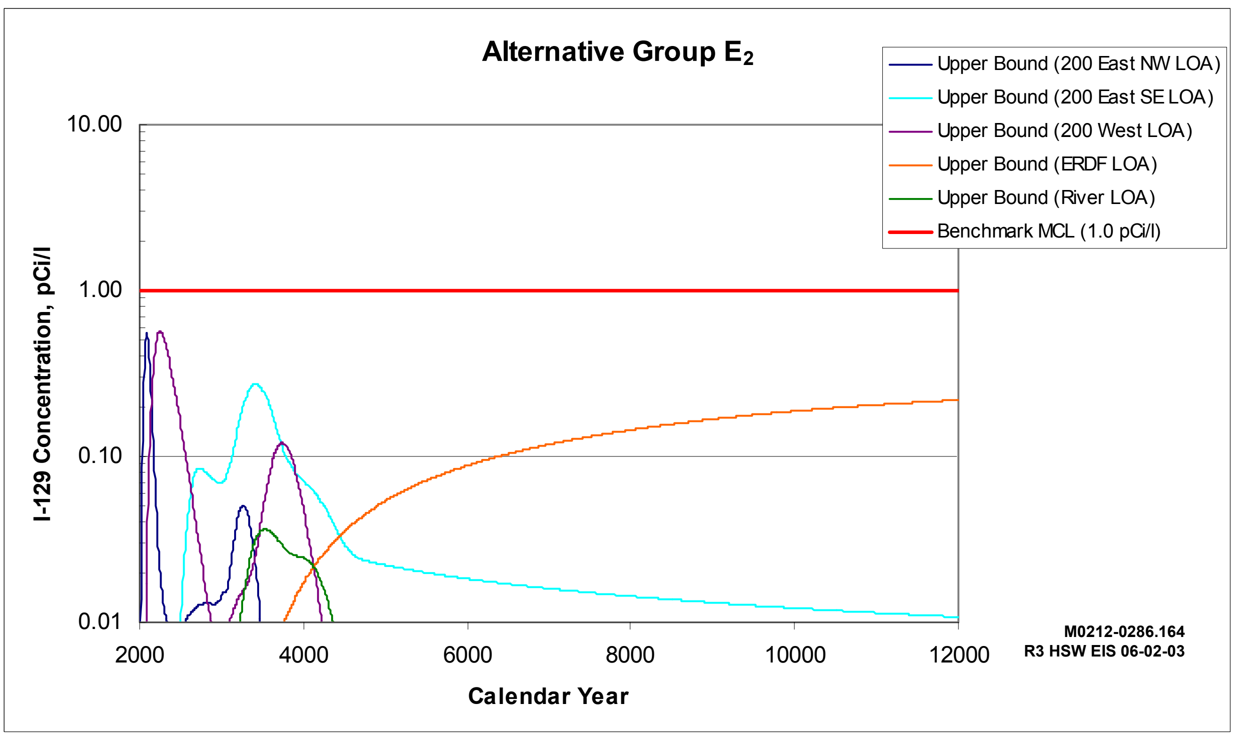


Figure 5.18. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group E_2 – Hanford Only and Upper Bound Waste Volumes)

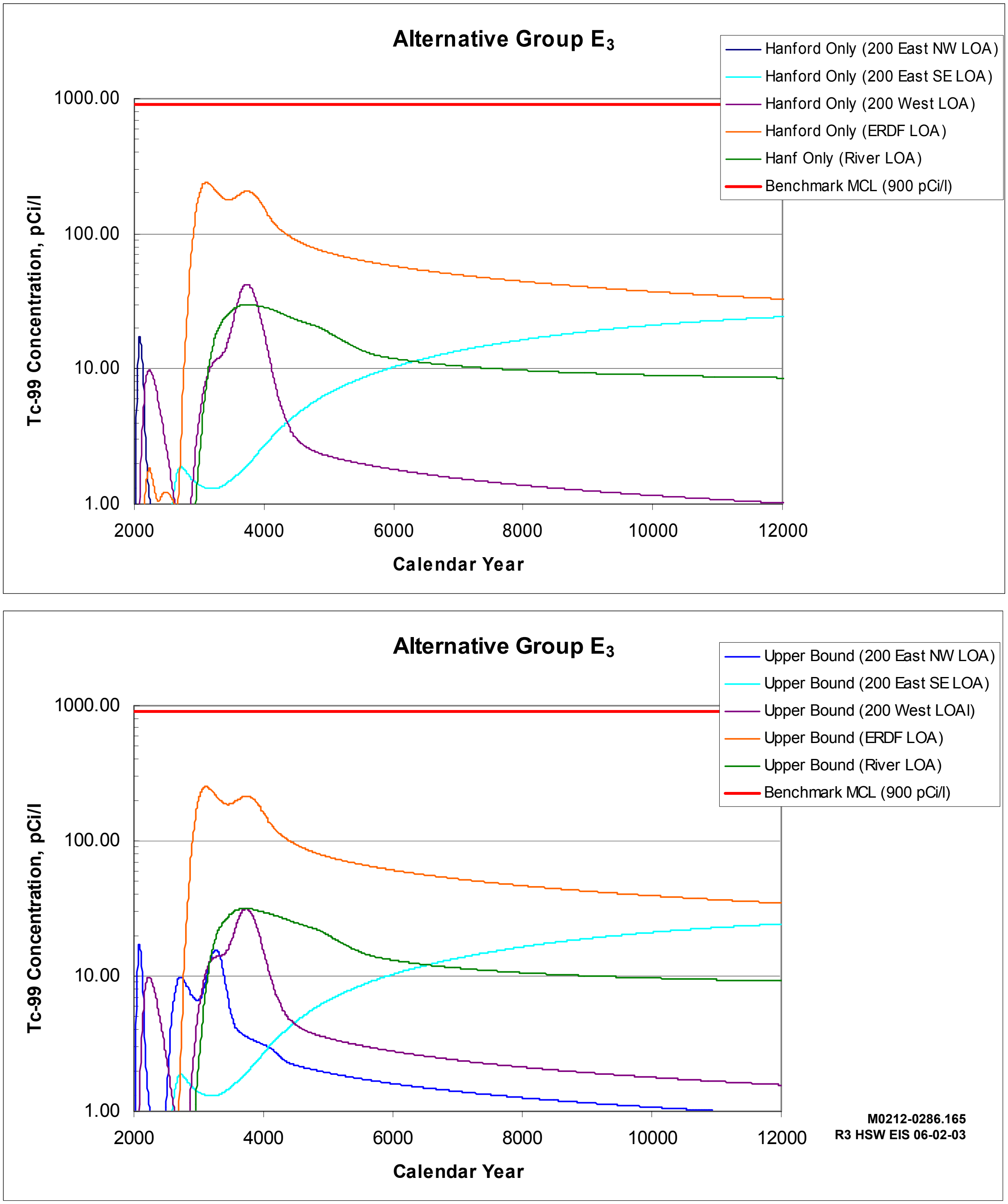


Figure 5.19. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group E_3 – Hanford Only and Upper Bound Waste Volumes)

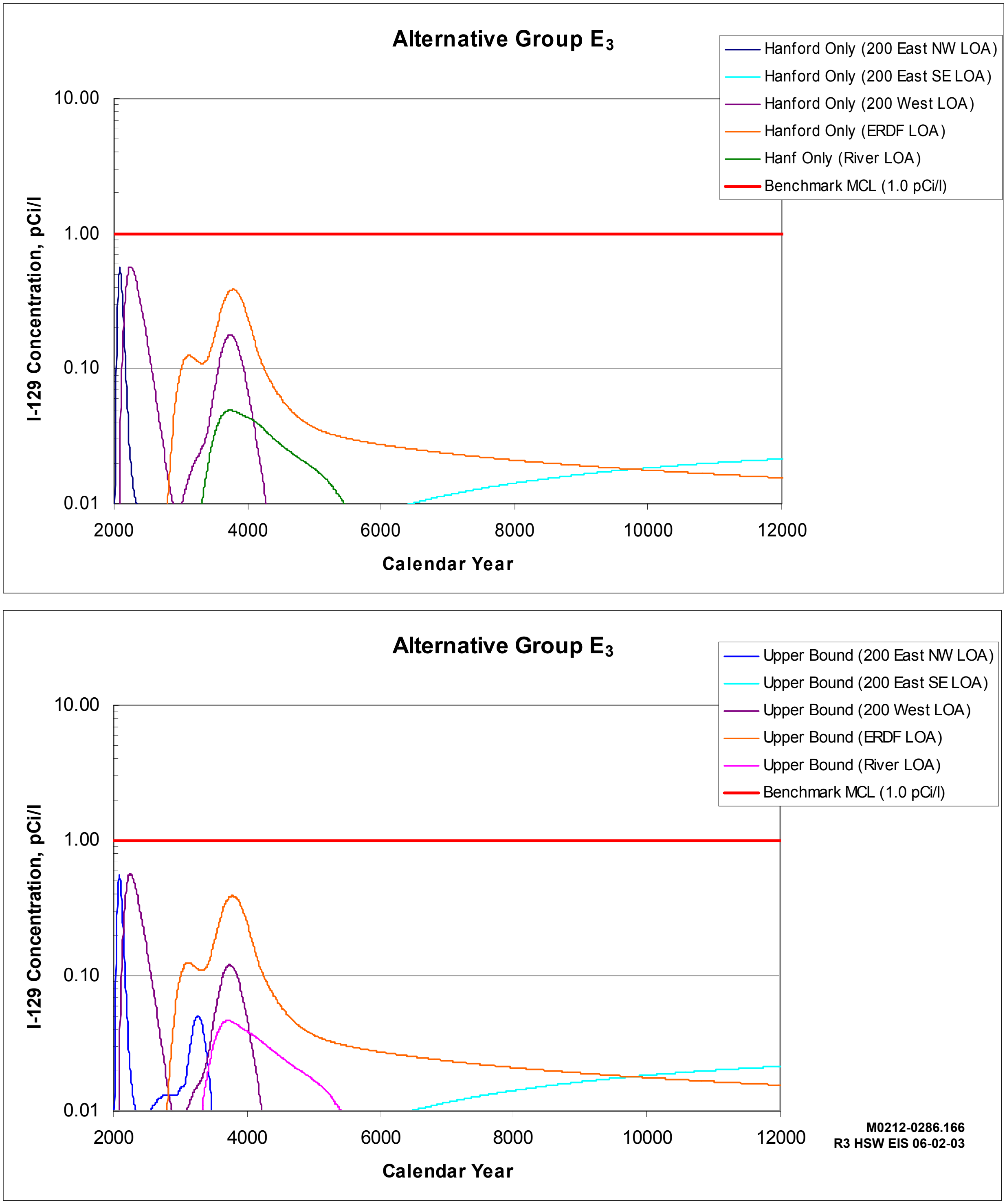
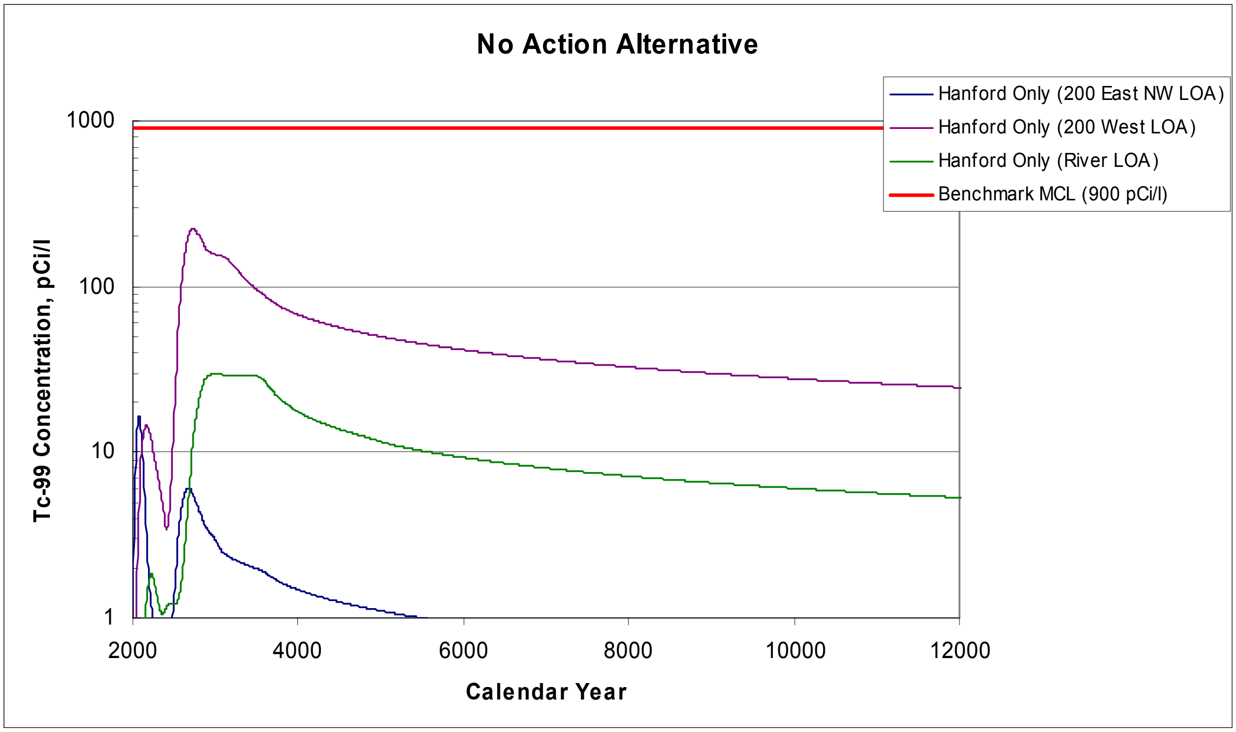


Figure 5.20. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group E_3 – Hanford Only and Upper Bound Waste Volumes)



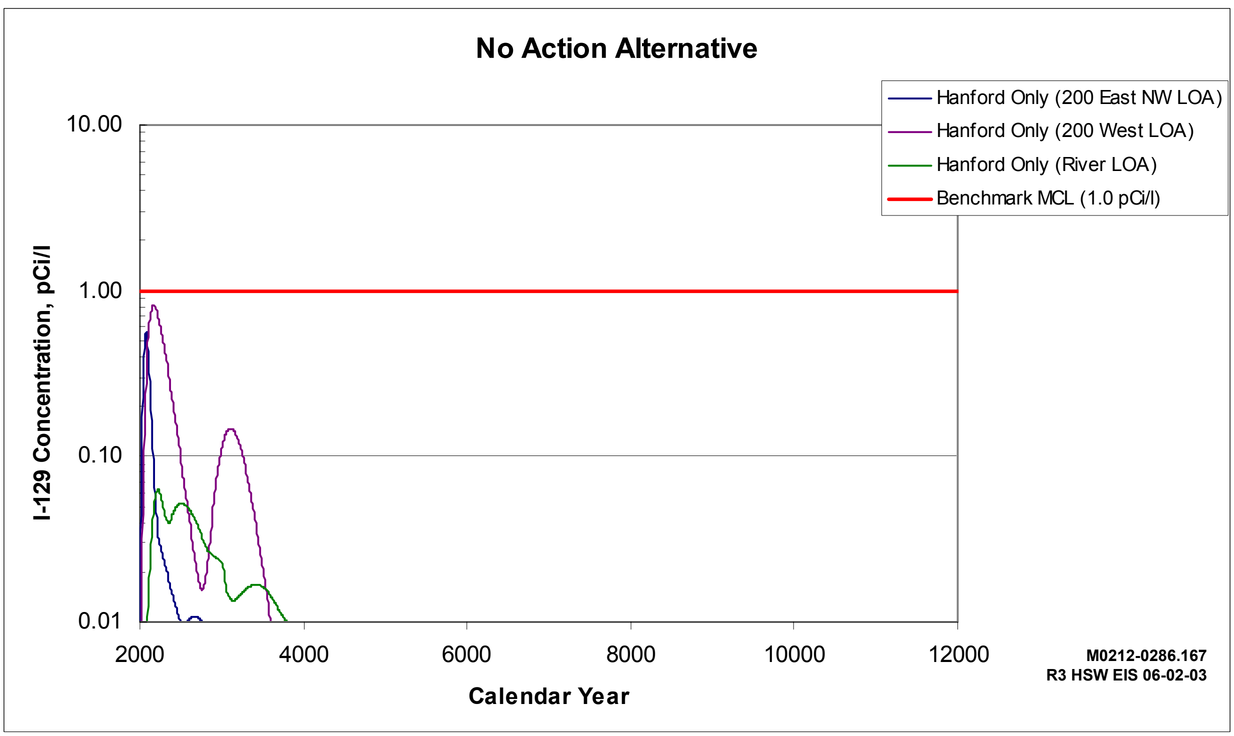


Figure 5.21. Technetium-99 and Iodine-129 Concentration Profiles at Various Lines of Analysis (No Action Alternative – Hanford Only Waste Volume)

5.3.4.1 Alternative Group A

LLW considered in Alternative Group A includes several different waste categories for disposal:

- pre-1970 LLW
- 1970–1987 LLW
- 1988–1995 LLW
- 1996–2007 Cat 1 and Cat 3 LLW and MLLW
- Cat 1 and Cat 3 LLW and MLLW disposed of after 2007 in deeper (18 m) (59 ft) and wider trenches in existing LLBGs 218-E-12B and 218-W-5
- melters disposed of after 2007 in a 21-m (69-ft) deep facility near the PUREX Plant
- ILAW disposed of after 2007 in a HSW disposal facility near the PUREX Plant.

Alternative Group A results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.3 and 5.4. These results show the potential impacts to groundwater quality at various lines of analysis starting in the year 2000. The potential impacts shown reflect: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.1.

5.3.4.1.1 Wastes Disposed of Before 1996

Constituents released from wastes disposed of before 1996 in the LLBGs that have the highest potential impact on groundwater quality are technetium-99 and iodine-129. Estimated combined technetium-99 and iodine-129 levels at the 200 East Area NW LOA peaked at about 110 years after the assumed start of release and at about 220 years after the assumed start of release at the 200 West Area LOA. Combined concentration levels of technetium-99 were relatively low (less than 20 pCi/L) at these 1-km LOAs and reflect about 2 percent of the benchmark maximum contaminant level for technetium-99 (900 pCi/L). The combined concentration level of iodine-129 at the 200 East NW LOA was about 60 percent (0.6 pCi/L) of the benchmark MCL. This concentration level resulted from releases of the iodine-129 inventory in the 1970–1987 LLW. The combined concentration level of iodine-129 at the 200 West Area LOA was about 50 percent (0.5 pCi/L) of the benchmark MCL. This concentration level also resulted from releases of the iodine-129 inventory in the 1970–1987 LLW.

Technetium-99 and iodine-129 combined concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA reached their peaks in about 260 years after the assumed start of release. Contaminant levels from sources in the 200 West Area reached their peaks along the Columbia River LOA between 500 and 600 years after the assumed start of release.

Carbon-14 and the uranium isotopes combined concentrations were found to peak at about or beyond the 10,000-year period of analysis. Carbon-14 concentrations at all LOAs were well below the benchmark MCL of 2000 pCi/L. Combined concentration levels of uranium-238, the dominant uranium isotope, also were well below the benchmark MCL at the 200 East and West Area LOAs at 10,000 years after site closure.

5.3.4.1.2 Wastes Disposed of After 1995

Potential groundwater quality impacts from wastes disposed of after 1995 also were highest for technetium-99 and iodine-129. Technetium-99 levels at the 200 East Area NW LOA were about 8 percent (75 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The source for these elevated levels is from technetium-99 released from the MLLW disposed of after 2007. Technetium-99 levels at the 200 West Area LOA were about 33 percent (300 pCi/L) of the benchmark MCL. The source of these potential impacts was primarily from the technetium-99 released from the Cat 3 LLW disposed of after 2007. Predicted technetium-99 releases were very similar for all waste volumes but were slightly higher for the Upper Bound waste volume.

Combined iodine-129 levels at the 200 East Area NW LOA were about 30 percent of the benchmark MCL of 1 pCi/L for the Hanford Only waste volume. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of MLLW disposed of after 2007. Iodine-129 levels at the 200 West Area LOA were about 15 percent of the benchmark MCL of 1 pCi/L for the Hanford Only waste volume. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This result is reflective of changes in partitioning the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks between 1550 and 1600 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river between 1600 and 2100 years after site closure.

Concentration levels of carbon-14 and the uranium isotopes at the LOAs did not reach their peak values until after the 10,000-year period of analysis and were well below benchmark MCLs at 10,000 years after site closure.

5.3.4.2 Alternative Group B

LLW considered in Alternative Group B includes the same waste considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW in conventional trenches after 2007 in LLBGs 218-E-12B and 218-W-5 and in the ILAW disposal facility located just south of the CWC.

Alternative Group B results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.5 and 5.6. As in Alternative Group A, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information is found in several tables and figures in Volume II, Appendix G, Volume II.

5.3.4.2.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.2.2 Wastes Disposed of After 1995

Under this alternative group, groundwater quality was most impacted by releases of technetium-99 and iodine-129 from disposed LLW and MLLW. Technetium-99 levels at the 200 East Area NW LOA were about 11 and 13 percent of the benchmark MCLs (95 and 116 pCi/L) for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in MLLW disposed of after 2007. These higher concentration levels are generally consistent with the broader surface area of releases associated with the use of conventional trenches under this alternative group.

Combined technetium-99 levels at the 200 West Area LOA were estimated to be about 33 percent (300 pCi/L) of the benchmark MCL of 900 pCi/L for the Hanford Only and Upper Bound waste volumes. These values are slightly less than levels estimated for Alternative Group A. However, this would be expected since the source of these potential impacts was primarily from the technetium-99 inventories in the Cat 3 LLW disposed of after 2007. Additionally, the use of conventional trenches under this alternative group would result in some of the inventory associated with Cat 1 and Cat 3 LLW disposed of after 2007 being emplaced in the 200 East Area.

Combined iodine-129 levels at the 200 East Area NW LOA were 42 and 47 percent (0.42 and 0.47 pCi/L) of the benchmark MCL of 1 pCi/L for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of the MLLW disposed of after 2007. Iodine-129 levels at the 200 West Area LOA were less than 8 percent (0.08 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The main contributor to these concentration levels was from iodine-129 inventories in the ungrouted part of the MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This impact is reflective of changes in partitioning the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Concentration levels of carbon-14 and the uranium isotopes at the LOAs downgradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark MCLs at 10,000 years after site closure.

Concentrations of all constituents were well below benchmark MCLs by the time they reached the Columbia River LOA. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area sources reached their peaks near the river at about 1500 years after site closure.

5.3.4.3 Alternative Group C

LLW considered in Alternative Group C includes the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW in a single, lined expandable trench and MLLW in another single, lined expandable trench after 2007 in LLBGs 218-E-12B and 218-W-5. The melters would be placed in a lined trench and ILAW would be placed in a single, expandable, lined trench near the PUREX Plant.

Alternative Group C results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.7 and 5.8. As in Alternative Groups A and B, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information is provided in several tables and figures in Volume II, Appendix G, Section G.2.3.

5.3.4.3.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.3.2 Wastes Disposed of After 1995

Because of assumptions in the source-term release and vadose zone modeling used for previously buried LLW and LLW and MLLW disposed of between 1996 and 2007 for Alternative Group C, results for this alternative group were the same for those waste categories calculated for Alternative Group A. Results for LLW and MLLW disposed of after 2007 for this alternative group were essentially the same as those presented in the figures for Alternative Group A. These results are consistent since the analysis assumption about waste depth and projected land use for waste disposed of after 2007 are the same for both alternative groups.

5.3.4.4 Alternative Group D_1

Wastes considered in Alternative Group D_1 are the same as those described for Alternative Group A. However, in this alternative group, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility near the PUREX Plant.

Alternative Group D_1 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.9 and 5.10. As was provided in the previous alternatives groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.4.

5.3.4.4.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.4.2 Wastes Disposed of After 1995

The highest potential impacts for this alternative group reflect the emplacement of all wastes disposed of after 2007 in the vicinity of the PUREX Plant. Potential impacts from LLW and MLLW are dominated by technetium-99 and iodine-129.

Combined concentration levels for technetium-99 were about 18 and 20 percent (167 and 185 pCi/L) of the benchmark MCL at the 200 East SE LOA for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in MLLW disposed of after 2007. Two peaks reflect technetium-99 inventories in both Cat 3 LLW and MLLW disposed of after 2007 near the PUREX area.

Combined technetium-99 concentration levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined iodine-129 concentration levels at the 200 East SE LOA were about 28 percent (0.28 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was iodine-129 inventories in ungrouted parts of the MLLW disposed of after 2007.

Combined iodine-129 levels at the 200 West Area LOA were about 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL for the for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels were slightly higher at the 200 East Area SE LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. These results are reflective of changes in partitioning of iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Combined concentration levels of carbon-14 and the uranium isotopes at the 200 East and West Area LOAs from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks near the river between 1400 and 1500 years after site closure. Contaminant levels at the same LOA from sources in the 200 West Area reached their peaks between 2100 and 2200 years after site closure.

5.3.4.5 Alternative Group D_2

Wastes considered in Alternative Group D_2 are the same as those described for Alternative Group A. However, in this alternative group, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility in LLBG 218-E-12B.

Alternative Group D_2 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.11 and 5.12. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.5.

5.3.4.5.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.5.2 Wastes Disposed of After 1995

The highest potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in the 218-E-12B LLBG. These potential impacts were primarily from technetium-99 and iodine-129.

Combined technetium-99 levels at the 200 East Area NW LOA were about 16 and 19 percent (148 and 169 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in Cat 3 LLW and MLLW disposed of after 2007.

Combined concentration levels of technetium-99 at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

The highest combined iodine-129 levels at the 200 East Area NW LOAs were about 28 percent (0.28 pCi/L) of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was ungrouted iodine-129 inventories in MLLW disposed of after 2007.

The highest combined iodine-129 levels were about 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL at the 200 West Area LOA for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

The highest combined iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This is reflective of changes in partitioning of the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Concentration levels of carbon-14 and the uranium isotopes at all LOAs did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below the benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks between 1500 and 1600 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river at about 2000 years after site closure.

5.3.4.6 Alternative Group D_3

Wastes considered in Alternative Group D_3 are the same as those described for Alternative Group A. However, in this alternative group, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility at ERDF.

Alternative Group D_3 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.13 and 5.14. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.6.

5.3.4.6.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.6.2 Wastes Disposed of After 1995

The highest potential groundwater quality impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF. Potential impacts were primarily from technetium-99 and iodine-129.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined technetium-99 levels at the 200 East Area NW LOA were about 2 percent (15.7 pCi/L) of the benchmark MCL for the Upper Bound waste volume. The primary source for these elevated levels was from inventories in MLLW disposed of between 1996 and 2007.

Combined technetium-99 levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined technetium-99 levels at the ERDF LOA were about 27 and 28 percent (242 and 253 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in the Cat 3 LLW disposed of after 2007.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined iodine-129 levels at the 200 East Area NW LOA were about 5 percent (0.05 pCi/L) of the benchmark MCL for the Upper Bound waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were about 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were slightly higher at the 200 East Area NW LOA and slightly lower for the Upper Bound waste volume. This result reflects assumed changes in partitioning of the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined iodine-129 levels at the ERDF LOA were 92 and 94 percent (0.92 and 0.94 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of after 2007.

Concentration levels of carbon-14 and the uranium isotopes at all LOAs downgradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels from sources in the 200 East Area reached their peaks near the river at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river at about 2000 years after site closure.

5.3.4.7 Alternative Group E_1

Alternative Group E_1 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.15 and 5.16. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.7.

5.3.4.7.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.7.2 Wastes Disposed of After 1995

Potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in LLBG 218-E-12B and disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative D_2. The highest potential impacts resulted from releases of technetium-99 and iodine-129.

Combined technetium-99 levels at the 200 East Area NW LOA were about 16 and 19 percent (148 and 169 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in Cat 3 LLW and MLLW disposed of after 2007.

Combined technetium-99 levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined technetium-99 levels at the ERDF LOA were about 0.3 percent (2.7 pCi/L) of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in the melters disposed of after 2007.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined iodine-129 levels at the 200 East Area NW LOA were about 5 percent (0.04 pCi/L) of the benchmark MCL for the Upper Bound waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were slightly higher at the 200 East Area NW LOA and slightly lower for the Upper Bound waste volume, which is reflective of changes in partitioning of the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined iodine-129 levels were 22 percent (0.22 pCi/L) at the ERDF LOA for both the Hanford Only and Upper Bound waste volumes. No iodine-129 inventory was estimated for melters disposed of at ERDF after 2007 for this alternative group.

Concentration levels of carbon-14 and the uranium isotopes at the LOA downgradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks near the river at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river at about 2000 years after site closure.

5.3.4.8 Alternative Group E_2

Results for Alternative Group E_2 for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.17 and 5.18. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.8.

5.3.4.8.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.8.2 Wastes Disposed of After 1995

Potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 near the PUREX Plant and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative Group D_1 (see Section 5.3.4.4.2). Results for the melters and ILAW were the same as those calculated for Alternative Group E_1 (See Section 5.3.4.7.2).

5.3.4.9 Alternative Group E_3

Alternative Group E_3 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.19 and 5.20. Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.9.

5.3.4.9.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A results in (see Section 5.3.4.1.1).

5.3.4.9.2 Wastes Disposed of After 1995

Potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF and the disposal of melters and ILAW near the PUREX Plant. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative Group D_3 (see Section 5.3.4.6.2). Results for the melters and ILAW were the same as those calculated for Alternative Group D_1 (see Section 5.3.4.4.2).

Combined technetium-99 levels were slightly less than 2.5 percent (22 pCi/L) of the benchmark MCL at the 200 East Area SE LOA for the Hanford Only waste volume. The potential impact for the Hanford Only waste volume reflects the potential impact of the melter and ILAW disposal near the PUREX Plant. The highest combined iodine-129 levels at the 200 East Area SE LOA were about 20 percent (0.2 pCi/L) of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes as a result of the ILAW disposal near the PUREX area.

5.3.4.10 No Action Alternative

The No Action Alternative for combined technetium-99 and iodine-129 concentration levels are summarized in Figure 5.21. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.10.

5.3.4.10.1 Wastes Disposed of Before 1996

The highest potential groundwater quality impacts from wastes disposed of before 1996 are related to technetium-99 and iodine-129 releases. Estimated concentrations of technetium-99 and iodine-129 peaked at about 110 years after the assumed start of release at the 200 East Area NW LOA and about 220 years after the assumed start of release at the 200 West Area LOA. Combined levels of technetium-99 were less than 2 percent (18 pCi/L) at the 200 East Area NW and the 200 West Area LOAs. Combined levels of iodine-129 at the 200 East Area NW LOA were less than 0.1 percent (0.09 pCi/L) of the benchmark MCL.

Combined levels of iodine-129 at the 200 West Area LOA were about 50 percent (0.5 pCi/L) of the benchmark MCL. This concentration level resulted from releases of the iodine-129 inventory in 1970-1987 LLW.

Concentration levels of carbon-14 and the uranium isotopes were found to peak at about or beyond 10,000 years after site closure. Carbon-14 concentrations were well below the benchmark MCL of 2000 pCi/L at the 200 East and West Area LOAs. Concentration levels of uranium-238, the dominant uranium isotope, were also well below the benchmark MCL of 30 pCi/L at the 200 East and West Area LOAs at 10,000 years after site closure. Uranium-238 concentrations reached a peak of about 3 pCi/L at their peak (between 14,000 and 16,000 years after site closure) at the 200 West Area LOA.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels from sources in the 200 East Area reached their peaks at the Columbia River LOA at about 260 years after the assumed start of release. Contaminant levels from sources in the 200 West Area reached their peaks at the Columbia River LOA between 500 and 600 years after the assumed start of release.

5.3.4.10.2 Wastes Disposed of After 1995

The highest potential groundwater quality impacts from LLW and MLLW disposed of after 1995 resulted from releases of technetium-99 and iodine-129. Combined technetium-99 levels at the 200 East Area NW LOA were about 8 percent (77 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The primary source for these elevated levels was from inventories in MLLW disposed of after 1995.

Combined technetium-99 levels were about 25 percent (225 pCi/L) of the benchmark MCL at the 200 West Area LOA. The source of these potential impacts was primarily from the technetium-99 inventory in Cat 3 LLW disposed of after 1995.

The highest combined iodine-129 levels were about 6 percent (0.06 pCi/L) of the benchmark MCL at the 200 West Area LOA for the Hanford Only waste volume. The main contributor to these concentration levels was from inventories in MLLW disposed of after 1995.

Concentration levels of carbon-14 and the uranium isotopes at the LOAs downgradient from source areas of LLW and MLLW disposed of after 1995 did not reach their peak values until after the

10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below the benchmark MCL by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks at about 850 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river between 1660 and 1820 years after site closure.

5.3.5 Effect of Long-Term Cover System Performance Assumptions

This section presents results from a set of cases that was evaluated to examine and illustrate the effect of changing assumptions related to cover system performance on predicted groundwater quality impacts. The cases evaluated were related to groundwater impacts from selected waste categories and configurations proposed under Alternative Group D_1. Two specific assumptions evaluated were as follows:

- No cover is assumed to exist and waste release is controlled by infiltration through natural vegetated surface conditions that likely would persist following site closure. The assumed infiltration rate for these conditions is 0.5 cm/yr.

- The Modified RCRA Subtitle C Cover system is assumed to persist for the entire period of analysis and waste release is assumed to be controlled by the cover design infiltration rate of 0.01 cm/yr.

The specific contaminants and waste categories evaluated in these sensitivity cases included ungrouted Upper Bound inventories of technetium-99 and iodine-129 contained in MLLW and ungrouted and grouted Upper Bound inventories of uranium-238 contained in MLLW (see Figures 5.22 and 5.23). These specific examples illustrate the effect of the cover assumptions for contaminants from Mobility Class 1 (K_d = 0.0 mL/g) and Mobility Class 2 (K_d=0.6 mL/g).

A comparison of results based on the current conservative cover system assumption of failure after 500 years and a return to natural infiltration within 500 years after failure produces very similar potential impacts to those predicted with the assumption that no cover system is used. For all cases examined, differences in the results show predicted peak concentrations at the 1-km LOA, based on the 500-year cover system assumption, to be slightly lower and to arrive about 600 to 700 years later than the calculated peak concentrations at the 1-km LOA for the no-cover assumption. The delay in arrival time is reflective of the effect of the lower infiltration and release rate that would be expected to occur when the cover system is assumed to operate at or near its design infiltration of 0.01 cm/yr for the first 600 to 700 years after closure.

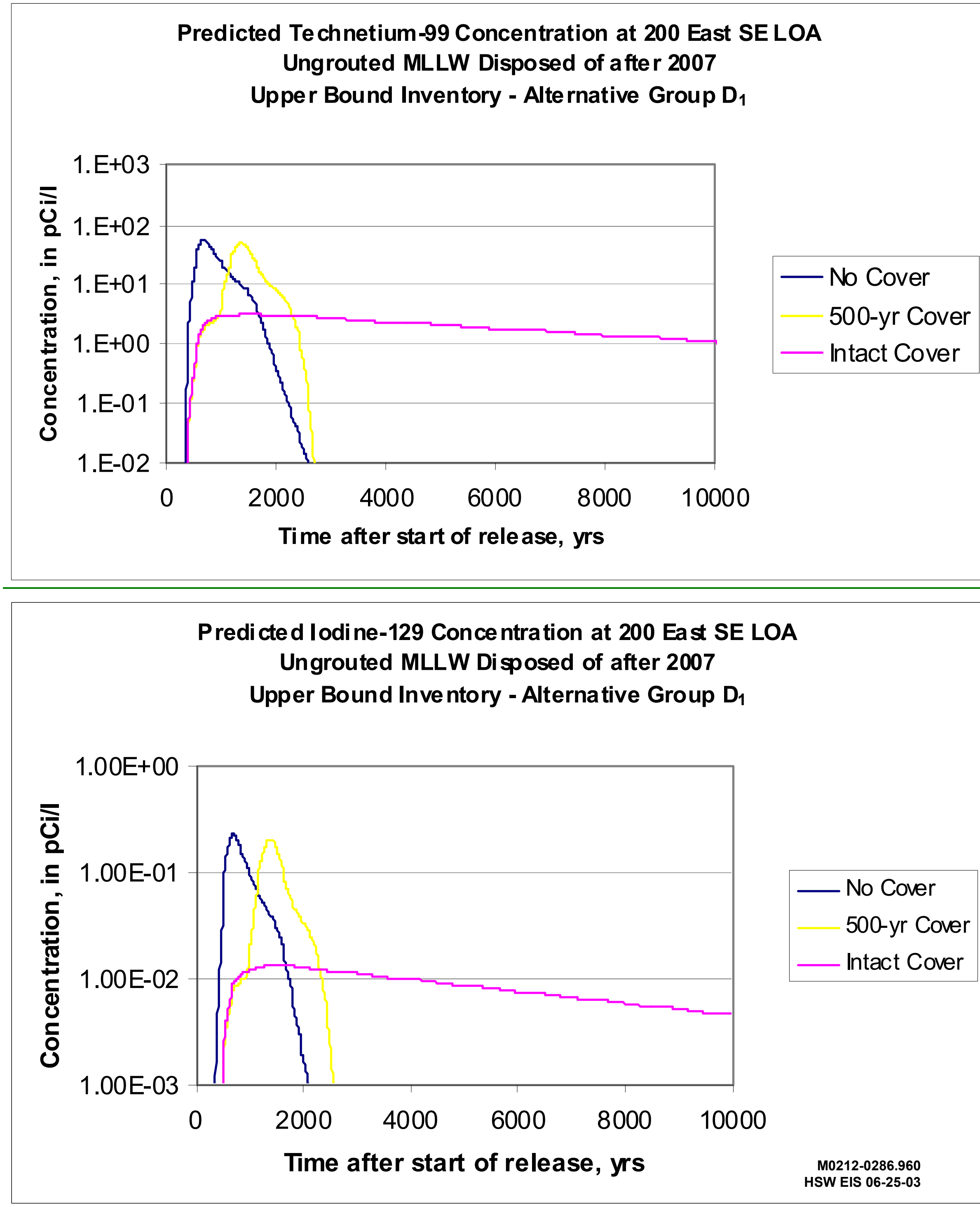


Figure 5.22. Comparison of Predicted Peak Concentrations of Technetium-99 and Iodine-129 at 200 East SE LOA from Upper Bound Inventories in Ungrouted MLLW Disposed of After 2007

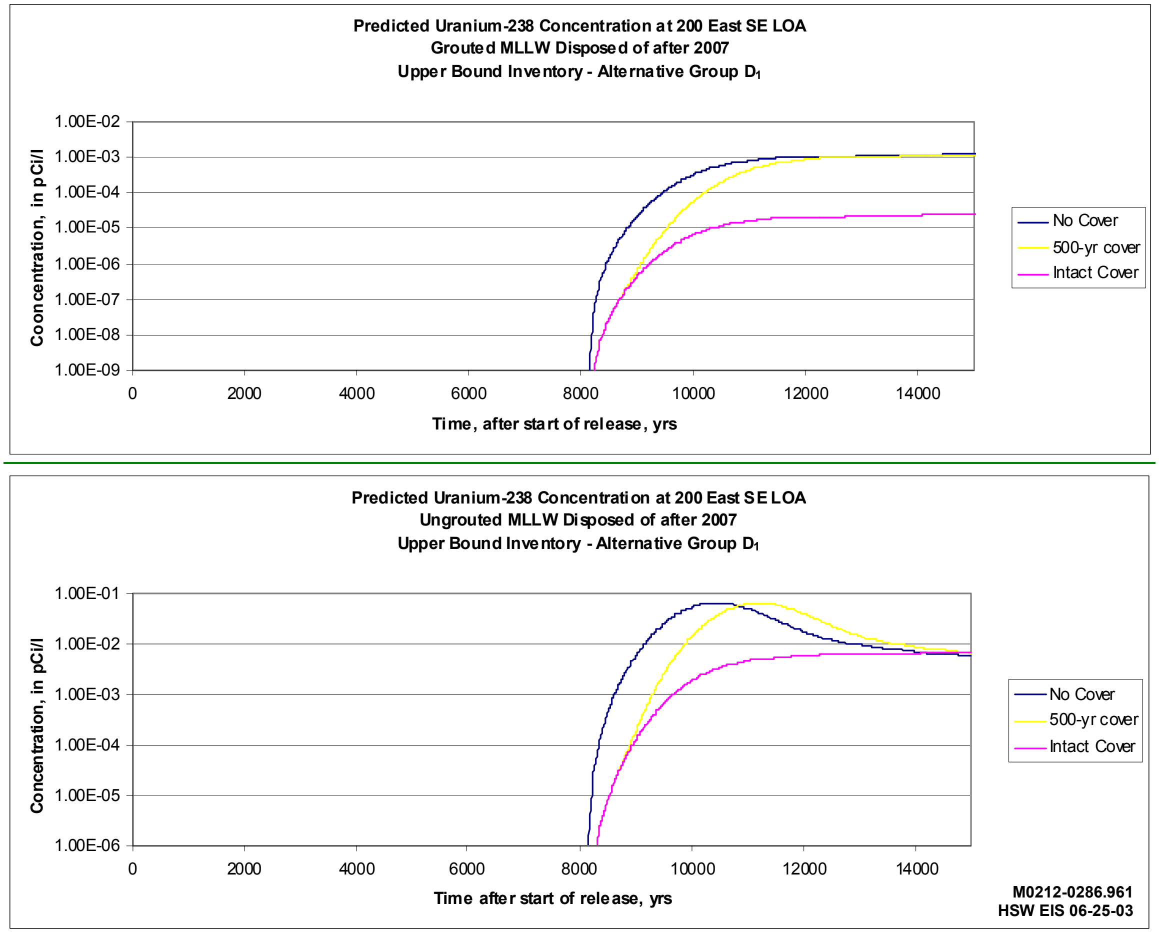


Figure 5.23. Comparison of Predicted Peak Concentrations of Uranium-238 at 200 East SE LOA from Upper Bound Inventories in Ungrouted and Grouted MLLW Disposed of After 2007

Figures 5.22 and 5.23 also compare resulting potential impacts using a calculational assumption where the cover system remains intact and does not fail during the period of analysis. For all cases examined, predicted peak concentrations at the 1-km LOA consistent with the intact cover system assumption are calculated to be about 7 percent of the peak and to arrive over a much longer period of time than the peak concentration arrival time at the 1-km LOA for the 500-year cover scenario (see Table 5.13). Results based on this assumption reflect the effect of the expected reduced infiltration and waste release from the waste disposal zone while the cover system is assumed to be intact and operating at its design infiltration rate of 0.01 cm/yr.

Table 5.13. Comparison of Predicted Peak Concentrations of Selected Constituents at the 200 East SE LOA from Upper Bound Inventories in Ungrouted MLLW Disposed of After 2007

	500-Year Cover		No Cover		Intact Cover	
	Peak Concentration (pCi/L)	Peak Arrival Time (yrs)	Peak Concentration (pCi/L)	Peak Arrival Time (yrs)	Peak Concentration (pCi/L)	Peak Arrival Time (yrs)
Ungrouted MLLW						
Tc-99	48.9	1,370	54.6	680	3.2	1,530
Iodine-129	0.21	1,370	0.23	680	1.3E-02	1,530
U-238	6.7E-02	11,200	6.7E-02	10,450	7.9E-03	20,000
Grouted MLLW						
U-238	1.42E-03	20,000	1.43E-03	20,000	2.8E-05	20,000

5.3.6 Potential Groundwater Quality Impacts at Waste Management Area Boundaries for Selected Alternatives

Potential impacts on groundwater for Alternative Groups D_1, D_2, and D_3 within 100 meters of the aggregate low-level waste management areas (LLWMAs) (see Volume II, Appendix G) are provided in this section. The alternative groups, waste types, and disposal conditions are briefly restated to establish the framework for comparing the results. These additional analyses of potential groundwater quality impacts for the new combined-use facility (as presented for Alternative Groups D_1, D_2, and D_3), also are presented in Section G.5 and provide a perspective on the relative potential impact at LLWMA boundaries about 100 meters downgradient of the aggregate waste disposal area versus potential impacts at the 1-km LOAs. A similar impact analysis is provided for LLW and MLLW disposed of before 2007 for another perspective. At the end of this section (Section 5.3.6.5), a qualitative discussion of estimates of impacts at LLWMA boundaries for Alternative Groups A, B, C, E, and the No Action Alternative are also provided.

Because of assumptions used in waste release, vadose zone transport, and introduction of constituent release to underlying groundwater, these analyses represent a very conservative evaluation, that is, an overestimate of potential water quality impacts in the vicinity of aggregate LLWMA boundaries (100 meters), and these analyses should not be considered a compliance analysis as required by DOE Order 435.1, RCRA closure, or CERCLA. The conservatism used in this analysis is particularly evident in the analysis of waste contained in LLBG 218-E-12B, where the aquifer system is predicted to become dry over the period of interest (see Volume II, Appendix G, Section G.5). Specific unit releases used to approximate potential impacts from waste categories and associated disposal areas were represented as a linear source just inside the aquifer system down-slope relative to the top of the basalt bedrock underlying this LLBG. This representation is a simplistic representation of the complex future migration of contaminants from this burial ground and resulting concentration levels estimated downgradient of LLWMA 2 likely would be substantially less than those reported here.

The broader comparative analysis of impacts at the 1-km LOAs presented in the previous section reflect a summation of predicted maximum concentrations for several waste categories regardless of their position on the LOA. These resulting concentrations also were used to provide a determination of the sum-of-fractions of benchmark MCLs for key constituents (that is, technetium-99 and iodine-129) for each alternative group. These results are presented in Section 5.3.6.4 and are also provided in Section 3.4 and the Summary of this HSW EIS. That approach, combining groundwater concentrations from separate waste sources, would not be appropriate for results of the LLWMA boundary analyses presented in this section because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category.

A discussion and summary of ratios to benchmark MCLs for technetium-99 and iodine-129 for each waste category in the three alternative groups (D_1, D_2, and D_3) are presented in Section 5.3.6.4.

5.3.6.1 Alternative Group D_1

Wastes considered in Alternative Group D_1 are the same as those described for Alternative Group A. However, in Alternative Group D_1, all wastes disposed of after 2007 would be placed in a single, lined, modular combined-use facility near the PUREX Plant. Results for waste disposed of before 2008 in Alternative Group D_1 are summarized in Table G.42 in Volume II, Appendix G. Waste disposed of after 2007 are summarized in Table G.43 in Volume II, Appendix G.

5.3.6.1.1 Wastes Disposed of Before 2008

Waste disposed of before 2008 consists of four categories: 1) pre-1970 LLW, 2) 1970–1987 LLW, 3) 1988–1995 LLW, and 4) 1996–2007 LLW and MLLW. The following sections provide brief summaries of potential groundwater quality impacts at about 100 meters downgradient from aggregate LLWMAs for each of these waste categories.

Pre-1970 Low-Level Waste

Pre-1970 LLW was primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-4C (LLWMA 4) in the 200 West Area. For these wastes, technetium-99 and iodine-129 released from the LLBGs would have the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 80 percent of the benchmark MCL and technetium-99, about 30 percent of the benchmark MCL 100 meters downgradient of LLWMA 2 in the 200 East Area. These resulting concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

1970–1987 Low-Level Waste

1970–1987 LLW was primarily disposed of in LLBGs 218-E-10 (LLWMAB (LLWMA 2) in the 200 East Area and in LLBG 218-W-4A (LLWMA 4), 218-W-3A, and 218-W-3E (LLWMA 3) in the 200 West Area. For these wastes, iodine-129 released from the LLBGs has the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 7 times higher than the benchmark MCL of 1 pCi/l 100 meters downgradient of LLWMA 2 in the 200 East Area. As in the case of pre-1970 LLW, these resulting concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II. Appendix G, Section G.5.3).

1988–1995 Low-Level Waste

1988–1995 LLW is primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area, and in LLBG 218-W-3A and 218-W-5 (LLWMA 3) in the 200 West Area. For these wastes, technetium-99 and iodine-129 released from the LLBGs would have the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 5 percent of the benchmark MCL 100 meters downgradient of LLWMA 2 in the 200 East Area. Technetium-99 is estimated to be about 7 percent of the benchmark MCL 100 meters downgradient of LLWMA 2 in the 200 East Area and about 9 percent of the benchmark MCL 100 downgradient of LLWMA 3 in the 200 West Area.

As in the case of pre-1970 LLW, concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

1996–2007 LLW and MLLW

1996–2007 wastes are and will be primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-3A and 218-W-5 (LLWMA 3) in the 200 West Area. Following is a brief summary of potential groundwater quality impacts from the three main components of these wastes, including Cat 1 LLW, Cat 3 LLW, and MLLW, as follows:

Category 1 LLW – Iodine-129 and technetium-99 released from 1996–2007 Cat 1 LLW primarily located in LLBG 218-W-5 within LLWMA 3 would have the highest potential impact on groundwater quality. Iodine-129 levels are estimated to be about 15 to 18 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 in the 200 West Area for the Hanford Only and Upper Bound waste volumes. Technetium-99 levels are estimated to be about 1 and 2 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 in the 200 West Area.

Category 3 LLW – Technetium-99 released from 1996–2007 Cat 3 LLW primarily located in LLBG 218-W-5 within LLWMA 3 would have the highest potential impact on groundwater quality. Technetium-99 levels are estimated to be about 2 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 in the 200 West Area.

MLLW – Technetium-99 and iodine-129 released from ungrouted 1996–2007 MLLW would have the highest potential impact on groundwater quality. Concentration levels of all constituents are below benchmark MCLs for grouted 1996–2007 MLLW.

Estimated technetium-99 concentrations are about 21 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 for all waste volumes. Estimated iodine-129 concentrations are about 48 and 80 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 for the Hanford Only and Upper Bound waste volumes and about equal to the benchmark MCL 100 meters downgradient of LLWMA 2 for the Upper Bound waste volume.

As in the case of pre-1970 LLW, concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

5.3.6.1.2 Waste Disposed of After 2007 Near the PUREX Plant

The potential impact for waste disposed of after 2007 reflects the emplacement of all wastes in the vicinity of the PUREX Plant. Potential impacts from LLW and MLLW would be dominated by technetium-99 and iodine-129.

The maximum potential impact from technetium-99 would be from Cat 3 LLW, where estimated concentration levels are about 21 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The maximum potential impact from iodine-129 would be from ungrouted MLLW, where estimated concentration levels are about 29 and 26 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes.

Estimated concentration levels of all other constituents in these waste categories and all constituents in other waste categories are well below benchmark MCLs.

5.3.6.2 Alternative Group D_2

Wastes considered in Alternative Group D_2 are the same as those described for Alternative Group D_1. However, in Alternative Group D_2, all wastes disposed of after 2007 would be placed in a single, lined, modular combined-use facility at LLBG 218-E-12B. Results for waste disposed of before 2008 in Alternative Group D_2 are summarized in Table G.42 in Volume II, Appendix G. Waste disposed of after 2007 are summarized in Table G.44 in Volume II, Appendix G.

5.3.6.2.1 Wastes Disposed of Before 2008

Because of assumptions in the source-term release and vadose zone modeling used for LLW disposed of before 2008 for Alternative Group D, results for Alternative Group D_2 are the same as those for waste categories calculated for Alternative Group D_1. These results are summarized in Table G.42 of Volume II, Appendix G.

5.3.6.2.2 Waste Disposed of After 2007 in LLBG 218-E-12B

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 in LLBG 218-E-12B. Potential impacts from LLW and MLLW would be dominated by technetium-99 and iodine-129 (see Volume II, Appendix G, Table G.44).

The maximum potential impact from technetium-99 would be from Cat 3 LLW, where estimated concentration levels are about 86 percent of the benchmark MCL for all waste volumes. The maximum potential impact from iodine-129 would be from ungrouted MLLW, where estimated concentration levels are about 94 and 95 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. In addition, the potential impact from iodine-129 would be from Cat 3 LLW, where estimated concentration levels are about 38 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. These higher levels of potential groundwater quality impacts relative to those calculated for similar waste inventories in Alternative Group D_1 reflect differences in aquifer conditions found beneath the near PUREX location (that is, high permeability and moderate saturated thickness of the Hanford formation at the water table) and the 218-E-12B LLBG (that is, slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table).

Estimated concentrations of all other constituents in these waste categories and all constituents in other waste categories would be below benchmark MCLs.

As in the case of other wastes disposed of in LLBG 218-E-12B, the resulting concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

5.3.6.3 Alternative Group D_3

Wastes considered in Alternative Group D_3 are the same as those described for Alternative Group D_1. However, in Alternative Group D_3, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility at ERDF. Results for waste disposed of before 2008 in Alternative Group D_3 are summarized in Table G.42 in Volume II, Appendix G. Waste disposed of after 2007 are summarized in Table G.45 in Volume II, Appendix G.

5.3.6.3.1 Wastes Disposed of Before 2008

Because of assumptions in the source-term release and vadose zone modeling used for LLW previously disposed of before 2008 for Alternative Group D, results for Alternative Group D_3 are the same as for those for waste categories calculated for Alternative Group D_1. These results are summarized in Table G.45 of Volume II, Appendix G.

5.3.6.3.2 Waste Disposed of After 2007

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 at ERDF. Potential impacts from LLW and MLLW would be dominated by technetium-99 and iodine-129 (see Volume II, Appendix G, Table G.45).

The maximum potential impact from technetium-99 would be from Cat 3 LLW, where estimated concentration levels are about 81 and 58 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. The maximum potential impact from iodine-129 would be from ungrouted MLLW, where estimated concentration levels are about 94 and 74 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes, respectively. In addition, the potential impact from iodine-129 from Cat 3 LLW would be about 36 and 28 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. These higher levels of potential groundwater quality impacts relative to those calculated for similar waste inventories in Alternative Group D_1 reflect differences between aquifer conditions found beneath the near PUREX location (that is, high permeability and moderate saturated thickness of the Hanford formation at the water table) and at ERDF (that is, lower hydraulic conductivities associated with the Ringold Formation at the water table).

Estimated concentrations of all other constituents in these waste categories and all constituents in other waste categories would well be below benchmark MCLs.

5.3.6.4 Summary of Ratios to Benchmark MCLs for Technetium-99 and Iodine-129

This section presents a discussion of the combined ratios of maximum potential concentrations to benchmark MCLs for technetium-99 and iodine-129 using the sum-of-fractions rule for all wastes considered in the three alternative groups. The breakdown is provided in two broad categories—1) waste disposed of before 2008 and 2) waste disposed of after 2007—and includes results for the Hanford Only and Upper Bound waste volumes.

5.3.6.4.1 Waste Disposed of Before 2008

The sum-of-fractions of maximum potential concentrations as compared with benchmark MCLs for technetium-99 and iodine-129 for waste disposed of before 2008, as presented in Table 5.14, are the same for all three alternative groups. Each waste category was evaluated as a separate entity because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category. Because of the higher waste containment integrity used for waste disposed of

Table 5.14. Sum of MCL Fractions and Drinking Water Doses from Maximum Potential Concentrations at LLWMA Boundaries for Technetium-99 and Iodine-129 for Waste Buried Before 2008

Primary Contributing Waste Category	200 East Area				200 West Area			
	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)
	Tc-99	I-129	Sum-of-Fractions[(a)]		Tc-99	I-129	Sum-of-Fractions	
Pre-1970 LLW	0.4	0.8	1.2	0.5	0.03	0.04	0.07	0.04
1970–1987 LLW	NA	7.2	7.2	1.5	NA	0.05	0.05	0.01
1988–1995 LLW	0.1	0.1	0.2	0.1	0.07	4.2	4.3	1.0
1996–2007 Cat 3 LLW								
Hanford Only	NA	NA	NA	NA	0.03	NA	0.03	0.03
Upper Bound	NA	NA	NA	NA	0.03	NA	0.03	0.03
1996–2007 MLLW								
Hanford Only	NA	NA	NA	NA	0.2	0.8	1.0	0.3
Upper Bound	0.3	1	1.3	0.5	0.1	0.5	0.7	0.2

(a) Sum-of-fractions greater than 1.0 would indicate a potential cumulative exceedance of benchmark MCLs.
NA = not applicable.

after 1995, waste releases of mobile constituents (that is, technetium-99 and iodine-129) to groundwater after 1995 would be delayed from release to groundwater from waste disposed of before or during 1995 by several hundred years.

As in the case for LLW disposed of in LLWMA 2 for Alternative Groups D_1 and D_2 (see Sections 5.3.6.1.1 and 5.3.6.2.1), concentration levels estimated 100 meters downgradient for LLW disposed of in LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

The largest sum-of-fractions were calculated from maximum potential concentrations estimated for iodine-129 contained in 1970–1987 wastes disposed of in LLBGs in the 200 East Area and in 1988–1995 LLW disposed of in LLBGs (mainly 218-W-5 and 218-W-3A) in the 200 West Area. The arrival of maximum concentration levels at the given LLWMA boundary were estimated to occur at about 90 years from the start of release in the 200 East Area and at about 150 years from the start of release for wastes in the 200 West Area. The assumed start of release for both areas was 1966. These relatively short arrival times of maximum concentrations reflect the assumptions used in the release of waste disposed of before 1995, that is, using a relatively high infiltration rate of 5.0 cm/yr in waste release and vadose zone transport. The maximum concentration would be expected to persist at the LLWMA boundary for a relatively short period of time (a few decades) after initial arrival and would dissipate within the period of active institutional control (that is, 100 years after site closure), during which time ground water use within the Central Plateau would be restricted.

As may be seen from Table 5.14, potential exceedances of benchmark MCLs using the sum-of-fractions rule (that is, sum-of-fractions greater than 1.0) are evident; however, it may also be noted that drinking water doses are below the benchmark DOE drinking water standard of 4 mrem/yr at the LLWMA boundary points of analysis.

5.3.6.4.2 Waste Disposed of After 2007

Combined ratios of maximum potential concentrations to benchmark MCLs for technetium-99 and iodine-129 for waste disposed of after 2007 are presented in Table 5.15 for all three alternative groups. In this case, the wastes would be disposed of within a combined-use facility. They are evaluated separately from the wastes disposed of before 2008 because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category. Because of the improved waste isolation and containment used in disposal of waste between 1996 and 2007, releases of mobile constituents (that is, technetium-99 and iodine-129) from these wastes to groundwater would be separated from releases to groundwater from waste disposed of before 1996 by several hundred years. In addition, the use of a glass waste form for waste in ILAW would cause releases of mobile constituents from these wastes to groundwater to be separated from releases to groundwater from waste disposed of before 1996 by several thousand years.

For the three alternative groups considered, the calculated sum-of-fractions would be lowest if the combined-use facility were sited near the PUREX Plant location (Alternative Group D_1). The higher levels of potential groundwater quality impacts at the 218-E-12B (Alternative Group D_2) and the ERDF (Alternative Group D_3) locations relative to the near-PUREX location reflect differences in aquifer conditions found beneath the 218-E-12B LLBG (slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table) and the ERDF (lower hydraulic conductivities associated with the Ringold Formation at the water table) locations.

For a combined-use facility near the PUREX Plant (Alternative Group D_1), Table 5.15 shows that the benchmark MCLs using the sum-of fractions rule would not be exceeded. For combined-use facilities at other LLWMA locations, potential exceedances of benchmark MCLs using the sum-of-fractions rule are evident; however, it should be noted that drinking water doses are below the DOE benchmark drinking water standard of 4 mrem/yr at the LLWMA boundary points of analysis.

Table 5.15. Sum of MCL Fractions and Drinking Water Doses from Maximum Potential Concentrations at Combined-Use Facility Boundaries for Technetium-99 and Iodine-129 for Waste Buried After 2007

Primary Contributing Waste Category	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)
	Technetium-99	Iodine-129	Sum-of-Fractions[a]	
Near the PUREX Plant (Alternative Group D_1)				
Cat 3 LLW				
Hanford Only	0.2	0.1	0.3	0.2
Upper Bound	0.2	0.1	0.3	0.2
MLLW				
Hanford Only	0.1	0.2	0.3	0.1
Upper Bound	0.1	0.2	0.3	0.1
Overall Totals				
Hanford Only	0.3	0.3	0.6	0.4
Upper Bound	0.3	0.3	0.6	0.4
218-E-12B LLBG (Alternative Group D_2)				
Cat 3 LLW				
Hanford Only	0.8	0.4	1.2	0.9
Upper Bound	0.8	0.4	1.2	0.9
MLLW				
Hanford Only	0.3	1.0	1.2	0.5
Upper Bound	0.3	1.0	1.2	0.5
Overall Totals				
Hanford Only	1.1	1.3	2.4	1.3
Upper Bound	1.1	1.3	2.4	1.3
ERDF (Alternative Group D_3)				
Cat 3 LLW				
Hanford Only	0.9	0.4	1.2	0.9
Upper Bound	0.9	0.4	1.2	0.9
MLLW				
Hanford Only	0.3	0.9	1.2	0.5
Upper Bound	0.3	0.9	1.2	0.5
Overall Totals				
Hanford Only	1.1	1.2	2.3	1.3
Upper Bound	1.1	1.2	2.3	1.3

(a) Sum-of-fractions greater than 1.0 would indicate a potential cumulative exceedance of benchmark MCLs.

5.3.6.5 Qualitative Estimates of Impacts at LLWMA Boundaries for Alternative Groups A, B, C, E, and the No Action Alternative

Although quantitative estimates of the impacts at the LLWMA boundaries were made only for Alternative Groups D_1, D_2, and D_3, those results were used to make qualitative estimates of impacts that might be expected from the other action alternative groups (that is, A, B, C, E_1, E_2, and E_3) and the No Action Alternative. The inferences are made based on evaluation of a combination of factors, including:

- similarities in assumed disposal configuration, mainly related to assumed waste depth
- similarities in hydrogeologic conditions at assumed disposal facility locations
- calculated ratios of predicted concentrations at the LLWMA boundaries and 1-km LOAs from similar source areas.

Ratios of predicted concentrations of the technetium-99 and iodine-129 calculated at the LLWMA boundaries and the 1-km LOAs were found to vary by waste category and disposal location. These ratios also vary within each LLWMA as a function of distance from the assumed disposal site to the LLWMA boundary. Calculated ratios for waste considered in Alternative Group D were found to vary as follows:

- Ratios for waste disposed of before 2008 varied from about 14 to 23 in the 200 East Area and from about 2 to 11 in the 200 West Area.
- Ratios for waste disposed of after 2007 varied from a low of 1.1 for waste assumed to be disposed of at the proposed facility near PUREX to a high of about 6 for waste assumed to be disposed of within the 218-E-12B LLBG.

The following sections provide a qualitative summary of impacts for the other action alternative groups (A, B, C, and E_1, E_2, and E_3) and the No Action Alternative for all wastes postulated to be disposed of before 2008 and wastes that would be disposed of after 2007. The primary focus of this discussion is on the impacts from technetium-99 and iodine-129, because these constituents are associated with potential maximum impacts.

5.3.6.5.1 Waste Disposed of Before 2008

Because the assumptions used in the source-term release and vadose zone modeling for LLW and MLLW postulated to be disposed of before 2008 were the same for all the action alternative groups, potential concentration levels of technetium-99 and iodine-129 estimated for Alternative Group D (see Table G.42 in Volume II, Appendix G) for waste disposed of before 2008 would be directly applicable for all the action alternative groups.

The impacts at the LLWMA boundaries presented in Table G.42 in Volume II, Appendix G for waste disposed of before 1996 generally would be applicable to concentration levels of technetium-99 and iodine-129 estimated for the No Action Alternative. Because of the assumptions used in the surface cover conditions, source release, and vadose zone transport for waste disposed of before 1996, the estimated maximum concentrations of technetium-99 and iodine-129 from these waste categories for the No Action Alternative were found to be similar to those estimated for the action alternative groups.

The impacts at the LLWMA boundaries presented in Table G.42 in Volume II, Appendix G for LLW and MLLW assumed to be disposed of between 1996 and 2007 also would be generally applicable to concentration levels of technetium-99 and iodine-129 estimated for LLW and MLLW assumed to be disposed of after 1995 in the No Action Alternative. However, maximum concentrations for technetium-99 and iodine-129 from waste disposed of after 1995 in the No Action Alternative would be expected to be higher for LLW and lower for MLLW due to the differences in assumed inventories of technetium-99 and iodine-129 between the No Action Alternative and the action alternative groups.

5.3.6.5.2 Waste Disposed of After 2007

The following sections provide a qualitative summary of potential groundwater quality impacts for LLW and MLLW assumed to be disposed of after 2007 with respect to Alternative Groups A, B, C, E_1, E_2, and E_3. The potential impacts for LLW and MLLW assumed to be disposed of after 2007 in the No Action Alternative were discussed in the previous section.

Alternative Group A

This alternative group evaluates the following disposal options:

- Cat 1 and Cat 3 LLW and MLLW disposed of after 2007 in deeper (18 m) (59 ft) and wider trenches in existing LLBGs 218-W-5 and 218-E-12B

- melters disposed of after 2007 in a 21-m (69-ft) deep facility near PUREX

- ILAW disposed of after 2007 in a new HSW disposal facility near PUREX.

For LLW disposed of after 2007 in LLBG 218-W-5 within the 200 West Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 3 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the Cat 1 and Cat 3 wastes disposed of between 1996 and 2007 in LLBG 218-W-5 in the 200 West Area in all the alternative groups. The ratio of results for technetium-99 and iodine-129 for LLW disposed of between 1996 and 2007 calculated at the LLWMA 3 boundary, shown in Table G.42 (see Volume II, Appendix G), and results at the 1-km LOA given for the same waste category (see Table G.7 in Volume II, Appendix G) suggest that concentrations at the LLWMA 3 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

For MLLW disposed of after 2007 in LLBG 218-E-12B within the 200 East Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 2 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the MLLW disposed of after 2007 in Alternative Group D_2. The ratio of results for technetium-99 and iodine-129 calculated at the LLWMA 2 boundary for the MLLW disposed of after 2007 in Alternative Group D_2, shown in Table G.42 (see Volume II,

Appendix G), and results at the 1-km LOA given in Table G.7 (see Volume II, Appendix G) suggest that concentrations at the LLWMA 2 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

Technetium-99 and iodine-129 results from disposal of melters and ILAW would be expected to be similar to those calculated for these facilities near PUREX in Alternative Group D_3 (see Table G.45 in Volume II, Appendix G).

Alternative Group B

LLW considered in Alternative Group B includes the same waste considered in Alternative Group A but assumes disposal of Cat 1 and Cat 3 LLW and MLLW in conventional trenches after 2007 in LLBGs 218-W-5 and 218-E-12B, melters in a trench in LLBG 218-E-12B, and ILAW in a new disposal facility located just south of the CWC.

For LLW disposed of after 2007 in LLBG 218-W-5 within the 200 West Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 3 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the Cat 1 and Cat 3 wastes disposed of between 1996 and 2007 in LLBG 218-W-5 in the 200 West Area for all the alternative groups. The ratio of results for technetium-99 and iodine-129 for LLW disposed of between 1996 and 2007 calculated at the LLWMA 3 boundary, shown in Table G.42 (see Volume II, Appendix G), and results at the 1-km LOA given for the same waste category (see Table G.7 in Volume II, Appendix G) suggest that concentrations at the LLWMA 3 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

For MLLW disposed of after 2007 in LLBG 218-E-12B within the 200 East Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 2 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the MLLW disposed of after 2007 in Alternative Group D_2. The ratio of results for technetium-99 and iodine-129 calculated at the LLWMA 2 boundary, shown in Table G.43 (see Volume II, Appendix G), and results at the 1-km LOA, given in Table G.22 (see Volume II, Appendix G), suggest that concentrations at the LLWMA 2 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

Results for the melters would be expected to be similar to those calculated for Alternative Group D_2 (see Section 5.3.6.2.2 and Table G.44 in Volume II, Appendix G). Results suggest that concentrations at the LLWMA 2 boundary would be about a factor of 5 greater than those presented for the 1-km LOA.

For ILAW disposed of after 2007 south of the CWC, the increase in concentrations at the LLWMA 4 boundary relative to the 1-km LOA for technetium-99 and iodine-129 would be expected to be similar to results for the Cat 1 and Cat 3 LLW disposed of after 2007 at ERDF in Alternative Group D_3. Although the disposal site south of CWC is several kilometers from the ERDF location, both disposal sites are in areas underlain with similar hydrogeologic units (that is, Ringold Formation Unit 5) that exist below the water table. The ratio of results for technetium-99 and iodine-129 calculated for Cat 1 and Cat 3 LLW at the ERDF boundary, shown in Table G.45 (see Volume II, Appendix G), and results at the 1-km LOA for the same waste category, given in Table G.25 (see Volume II, Appendix G), suggest that concentrations at the ERDF boundary would be about a factor of 3 greater than those presented for the 1 km LOA.

Alternative Group C

Because of assumptions in the source-term release and vadose zone modeling used for previously buried LLW and LLW and MLLW disposed of after 2007 for Alternative Group C, results for LLW and MLLW disposed of after 2007 for this alternative group, including the ILAW and melters, would be expected to be similar to those qualitatively discussed for Alternative Group A. These results are consistent because the analysis assumption about waste depth and projected land use for waste disposed of after 2007 are the same for both alternative groups.

Alternative Group E_1

The potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in LLBG 218-E-12B and disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 would be expected to be similar to results for the same wastes in Alternative D_2 (see Table G.44 in Volume II, Appendix G). Results for the disposal of melters and ILAW would be expected to be similar to those calculated for these facilities in Alternative Group D_3 (see Table G.45 in Volume II, Appendix G).

Alternative Group E_2

The potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 near PUREX and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 would be expected to be similar to results for the same wastes in Alternative Group D_1 (see Section 5.3.6.1.2 and Table G.43 in Volume II, Appendix G). Results for the melters and ILAW would be expected to be similar to those calculated for Alternative Group D_3 (see Section 5.3.6.3.2 and Table G.45 in Volume II, Appendix G) and Alternative Group E_1 (see the preceding paragraph).

Alternative Group E_3

The potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF and the disposal of melters and ILAW near PUREX. Results for LLW and MLLW disposed of after 2007 would be expected to be similar to results for the same wastes in Alternative Group D_3 (see Section 5.3.6.3.2 and Table G.45 in Volume II, Appendix G). Results for the melters and ILAW would be expected to be similar to those calculated for Alternative Group D_1 (see Section 5.3.6.3.1 and Table G.43 in Volume II, Appendix G).

5.3.6.5.3 Summary of Results for Disposal Alternatives

Results of the detailed analyses of the subalternatives in Alternative Group D and the qualitative analysis of for the other Alternative Groups (A, B, C, and E) at LLWMA boundaries lead to the following general conclusions:

- The range of potential groundwater quality impacts at disposal facility boundaries for the alternative groups is largely reflective of differences in hydrogeologic conditions found beneath different postulated disposal facility locations. Differences in potential impacts also are, to a lesser extent, a function of assumed disposal facility configurations.

- Maximum concentrations of technetium-99 and iodine-129 conservatively estimated from a combined-use facility at the range of disposal facility locations yielded potential exceedances of benchmark MCLs using the sum-of-fractions rule for two of the subalternatives in Alternative Group D. However, associated drinking water doses were found to be below the DOE benchmark drinking water standard of 4 mrem/yr at the LLWMA boundary points of analysis for the subalternatives in Alternative Group D. Detailed analysis of the other alternative groups (A, B, C, and E) likely would lead to the same general human health impact (that is, estimated potential drinking water doses would be below the DOE benchmark drinking water standard of 4 mrem/yr at the LLWMA or disposal area boundary points of analysis).

- From the standpoint of estimated impacts at LLWMA boundaries, the most favorable alternative for LLW and MLLW disposed of after 2007 appears to be Alternative Group D_1 where all LLW and MLLW, including melters and ILAW, are assumed to be disposed of near the PUREX Plant. This site would have the lowest estimated impacts because of the high permeability and moderate saturated thickness of the Hanford formation sediments found at the water table beneath this location.

- For the same assumed LLW and MLLW inventories, higher impacts would be expected at the LLWMA boundaries for alternative groups that consider disposal of wastes within the 218-W-5 and 218-E-12B LLBGs and at the ERDF location. These impacts would be expected to be higher because of the hydrogeologic conditions found at the water table at these locations (that is, slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table at the 218-E-12B LLBG and the lower permeability of the Ringold Formation found at the water table at the 218-W-5 LLBG and ERDF locations).

5.3.7 Potential Groundwater Quality Impacts from Hazardous Chemicals in Pre-1988 Wastes

In response to comments received during the public comment periods on the drafts of the HSW EIS, efforts were made to develop an estimate of quantities of potentially hazardous chemicals in previously buried LLW so that potential impacts of such chemicals on groundwater quality could be evaluated. The estimation of these inventories, which used a waste stream analysis estimation method, is summarized in the Technical Information Document (FH 2004).

The most substantial quantities of hazardous chemicals (in terms of inventory quantities) identified from this effort are summarized in Table 5.16. These specific, selected hazardous chemical inventories provided the basis for the following analysis of potential groundwater quality impacts from hazardous chemical inventories in wastes disposed of before 1988.

Table 5.16. Estimated Inventories of Selected Hazardous Chemicals Potentially Disposed of in HSW LLBGs Between 1962 and 1987

Constituent	Inventory (kg)
Chromium	100
Fluoride	5,000[a]
Nitrate	5,000[b]
Lead	>600,000
Mercury	1,000
1,1,1-trichloroethane	900
Xylene	3,000
Toluene	3,000
Methylene chloride	800
Oil	3,000
Diesel fuel	20,000
Hydraulic fluid	40,000
PCBs	8,000

(a) Fluoride mass equivalent for 10,000 kg of sodium fluoride.
(b) Nitrate mass equivalent to 6,000 kg of sodium nitrate.

5.3.7.1 Contaminant Group and Screening Analysis

As was done in the impact analysis for radiological constituents, the potential for each of the hazardous chemical constituents to impact groundwater was evaluated. Screening of these constituents evaluated their relative mobility in the subsurface system within a 10,000-year period of analysis. In addition, because of the presence of several organic chemicals in the table, the screening also considered the potential for chemical degradation within the period of analysis.

As in the radiological constituent analysis, the constituents were grouped based on their mobility in the vadose zone and underlying unconfined aquifer using estimated or assumed K_d for each constituent as a measure of mobility. A summary of all hazardous constituents using the same mobility groupings (based on K_d values) described in Section G.1.3.1 is provided in Table G.49 (both in Volume II, Appendix G).

The mobility of constituents in Table G.49 in Volume II, Appendix G were further evaluated using estimates of constituent transport times through the thick vadose zone to the unconfined aquifer during the 10,000-year period of analysis described in Section G.1.3.1. Based on a natural infiltration rate of 0.5 cm/yr through the underlying vadose zone (see the screening analysis method described in Volume II, Appendix G, Section G.1.3.1) and the estimated levels of sorption and associated retardation for each of the classes above, travel times of all constituents were estimated. Results of this analysis show that without a substantial driving force, arrival times of constituents within Mobility Classes 3, 4, and 5 through the thick vadose zone to the unconfined aquifer beneath the LLBGs were calculated to be well beyond the 10,000-year period of analysis. Thus all constituents in these classes were eliminated from further consideration. The constituents eliminated from further consideration include diesel fuel, hydraulic fluid, oil, lead, mercury, and PCBs.

Because the constituent list evaluated includes a few volatile organic chemicals, the effect of potential biotic and abiotic degradation and volatization also were examined in the constituent screening process. Table G.50 (see Volume II, Appendix G), which provides generic estimates of the biotic and abiotic degradation for selected chemicals, suggests that degradation, particularly biotic degradation, may be an important factor in reducing inventories of the organic constituents in question. Table G.51 (see Volume II, Appendix G), which provides some laboratory estimates of volatilization rates, suggests that this process also would be important. Consideration of relatively high degradation and volatilization rates for the compounds in question provided the basis for eliminating the volatile organic chemicals within Mobility Class 1 including: 1,1,1-trichloroethane, xylene, toluene, and methylene chloride. No contaminants were identified in Mobility Class 2.

While these organic compounds would be expected to be reduced in source areas by the processes of degradation and volatilization, the impact from breakdown products generated from degradation of the constituents in question potentially exists. While these impacts were not evaluated in detail, the general types of by-product compounds that could be formed were examined qualitatively to identify other potential constituents of concern.

Breakdown products from the above constituents may be produced from combinations of three subsurface processes. Two of these processes include biotic degradation by microorganisms under aerobic or anaerobic conditions. In the absence of viable microbial populations, abiotic degradation, which usually occurs as a result of chemical hydrolysis of the constituent, may also occur. Breakdown of these constituents have generally established degradation pathways resulting in the formation of a number of intermediate breakdown products. Intermediate breakdown products that are regulated would be of most interest from an impact perspective.

A review of established degradation pathways for the four constituents (Jordan and Payne 1980; Truex et al. 2001; Vogel et al. 1987) identified two regulated byproducts of greatest potential concern: 1,1-dichloroethene and vinyl chloride, which would be associated with degradation of 1,1,1-trichloroethane. Methylene chloride produces chloromethane as a breakdown product (EPA 2000a), but chloromethane is not regulated compound. Toluene and xylene produce breakdown products that are common constituents found in lignin (woody materials) and that break down in natural biological cycles. Such breakdown products are not regulated (EPA 2000a).

The final list of constituents considered for further analysis include the remaining inorganic chemicals in Mobility Class 1—chromium, fluoride, and nitrate.

5.3.7.2 Methods and Other Key Assumptions

The following hypothetical groundwater quality impacts associated with hazardous chemicals contained in waste disposed of before 1988 were based on the same source-term release and vadose transport calculations for the main comparative analysis described in Volume II, Appendix G, Sections G.1.3 and G.1.4, for this waste category. Little is known about the actual quantities and distribution of hazardous chemicals, hence the analysis based on the estimated inventory of the selected constituents should be considered an approximation of the potential impacts from these hazardous chemicals in disposed of wastes. For purposes of these calculations, the entire hazardous chemical inventory was conservatively assumed to be uniformly disposed of in wastes contained within the 218-W-4B LLBG in the 200 West Area. The wastes currently disposed of in this LLBG are wastes disposed of prior to 1970.

This analysis made use of the unit-release calculations for pre-1970 wastes in the local-scale groundwater model developed for the 200 West Area described in Volume II, Appendix G, Section G.5.1. The underlying assumptions and analysis characteristics associated specifically with the analysis for pre-1970 LLW described in Section G.5.1 provided the basis for the results described here.

5.3.7.3 Summary of Results

Based on the estimated inventories of the listed constituents assumed to be disposed of before 1988, summarized in Table 5.16 (Volume II, Appendix G), the analysis showed that potential groundwater quality impacts from such hazardous chemicals would not be expected to be substantial. A screening analysis that considered a combination of contamination mobility (due to sorption) and the potential contaminant degradation (due to biotic degradation and volatilization) reduced the initial number of inorganic and organic constituents with the most significant inventories to a list of three chemicals—chromium, fluoride, and nitrate.

For conditions where all of the estimated hazardous chemical inventories for these constituents are hypothetically emplaced in the 218-W-4B LLBG in the 200 West Area, estimated concentration levels at about 100 meters downgradient of the associated low-level waste management area (for example, LLWMA 3) were found to be below benchmark MCLs for all three chemicals (see Table 5.17).

Table 5.17. Estimated Peak Concentrations in Groundwater from Selected Hazardous Chemicals in Waste Hypothetically Disposed of in HSW LLBGs Before 1988

Constituent	Benchmark MCL (mg/L)	Inventory (Kg)	Maximum Concentration[(a)] (mg/L)	Approximate Peak Arrival Time (yrs)
Chromium	0.10	100	0.02	140
Fluoride	4.0	5000[(b)]	1.0	140
Nitrate	10.0[(c)]	5000[(d)]	0.25[(e)]	140

(a) Results are based on hypothetical disposal of these wastes in LLBG 218-W-4B in the 200 West Area, and concentration levels reflect levels estimated at about 100 m downgradient of the LLWMA 4 boundary.
(b) Fluoride mass equivalent in 10,000 kg of sodium fluoride.
(c) Benchmark maximum contaminant level for nitrate is expressed as nitrogen.
(d) Nitrate mass equivalent for 6,000 kg of sodium nitrate.
(e) Concentration expressed as nitrogen.

Actually, waste disposed of before 1988 can be found within multiple burial grounds in the 200 East Area within the 218-E-10 and 218-E-12B LLBGs and in the 200 West Area primarily within the 218-W-4B, 218-W-4C, 218-W-3A, and 218-W-3AE LLBGs. Use of alternative assumptions that would distribute the estimated inventory to multiple LLBGs would result in further reductions in estimated concentration levels at aggregate LLWMA boundaries.

Final closure or remedial investigations of these facilities under RCRA and/or CERCLA guidelines could involve further evaluation of historical waste records, more detailed waste characterization, and a more comprehensive analysis of the potential impacts of the chemical components of these inventories, including potential degradation products.

Results from this qualitative assessment suggest that potential groundwater impacts from the estimated hazardous chemicals inventories hypothetically contained in HSW disposed of before 1988 would not be substantial. This analysis also shows that a substantially larger hazardous chemical inventory would need to be specified for the constituents considered before impacts would approach current benchmark standards.